POWER

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The Maintenance of the Navy

SECRETARY Hughes' proposal for a reduction of naval armament has been received with universal approval. May that approval crystallize into the indorsement of an accomplished fact.

God speed the day when we can do away with it altogether and look back upon the carrying of navies by the nations as we do upon the carrying of swords by our ancestors.

But so long as we keep any navy at all, let us keep it right.

The Bureau of Engineering gets forty cents a horsepower for the repair and upkeep of the motive power of our fleets where ten years ago it got one dollar.

And a dollar went farther in those days.

This is not so impossible as it looks. We have more horsepower, so that the gross expenditure is not reduced in that proportion. We have units of greater capacity, requiring less attention per unit output, and we have improved apparatus, material and methods that permit us to get through with less repairs and overhauling per horsepower.

The development of steam engineering is making possible many reductions in operating costs, but it takes money to put them into effect.

In a battleship where the makeup water is evaporated by the use of live steam from the boilers, the installation of triple- or quadruple-effect evaporators operated with exhaust steam from the auxiliaries would save tons of fuel oil and pay for itself inside of two years. But they cannot be installed on a parsimonious appropriation.

Rods fair and true, metallic-packed, bearings carefully lined, pumps and auxiliaries not simply in working order but in the pink of condition, the farthest away from possible breakdown, a trained personnel in a state of as acute readiness as is the machinery under their charge—those are the kind of things that brought the "Oregon" around the Horn with the need of no repairs or renewals beyond four grate bars.

But can it be done on forty per cent per horsepower of what was required a decade ago with no money for revisions that might make it possible?

Let us not let the Navy get the idea that it is getting out of fashion and ready for the rummage sale. Let us not get the idea ourselves that the Navy will never be used and should be allowed to die off with as little expense as possible. We hope that we shall never send another ship upon any other than a friendly mission; we hope that we shall never fire another gun except in practice or salute; we hope that the day will come when the picture of a battleship will be as curious as that of a Roman galley. We are going to try our best to realize this hope. But until we are sure that the rest of the world is of the same mind and the national brigands and pirates dead or reformed, we shall have to keep our powder dry and some shot in the locker.

F. R. Low

Distilled Water for Boiler Feed at River Rouge Plant

An elaborate two-effect high-heat-level evaporator system furnishes distilled makeup to an amount up to 25 per cent of the boiler feed. Through a ring header system water is fed to the sealed-off section in the lower drum of each boiler element. Water from this section must pass up through the four last rows of tubes in the third pass before entering the general circulation.

IN RECENT articles a general outline was given of the mechanical equipment of the new River Rouge plant of the Ford Motor Co., with the exception of the boiler-feed system, which will be the subject of the present article. As the raw water available from River Rouge contains considerable suspended and scale-forming matter, the engineering staff of the Ford company decided to install an elaborate high-pressure evaporator system, which in the early stages of the plant would supply distilled makeup to an amount approximating 25 per cent of the boiler feed, and later on, when the eight-boiler plant is complete and the mechanical load is relatively larger, about 15 per cent of the water going to the boilers. This large amount of makeup, about five times the usual requirement of large central stations, was necessary because of the use of large quantities of steam for process work, the nature of which prohibited the return of condensation to the power plant. The factors influencing the decision were the nature of the water, the quantity of makeup required, the high load factor on the boiler plant and the importance of maintaining uninterrupted service with the normal operation averaging 250 per cent of boiler rating and on peaks running up to 400 per cent of the nominal capacity. Return on the investment was anticipated from the elimination of troubles attributable to impure makeup water, such as scale, foaming and frequent blowing down of the boilers. Indirectly, the system was expected to be a contributing factor toward preventing shutdowns, the enormous size of the boilers making it costly to shut down for cleaning and maintaining high efficiency.

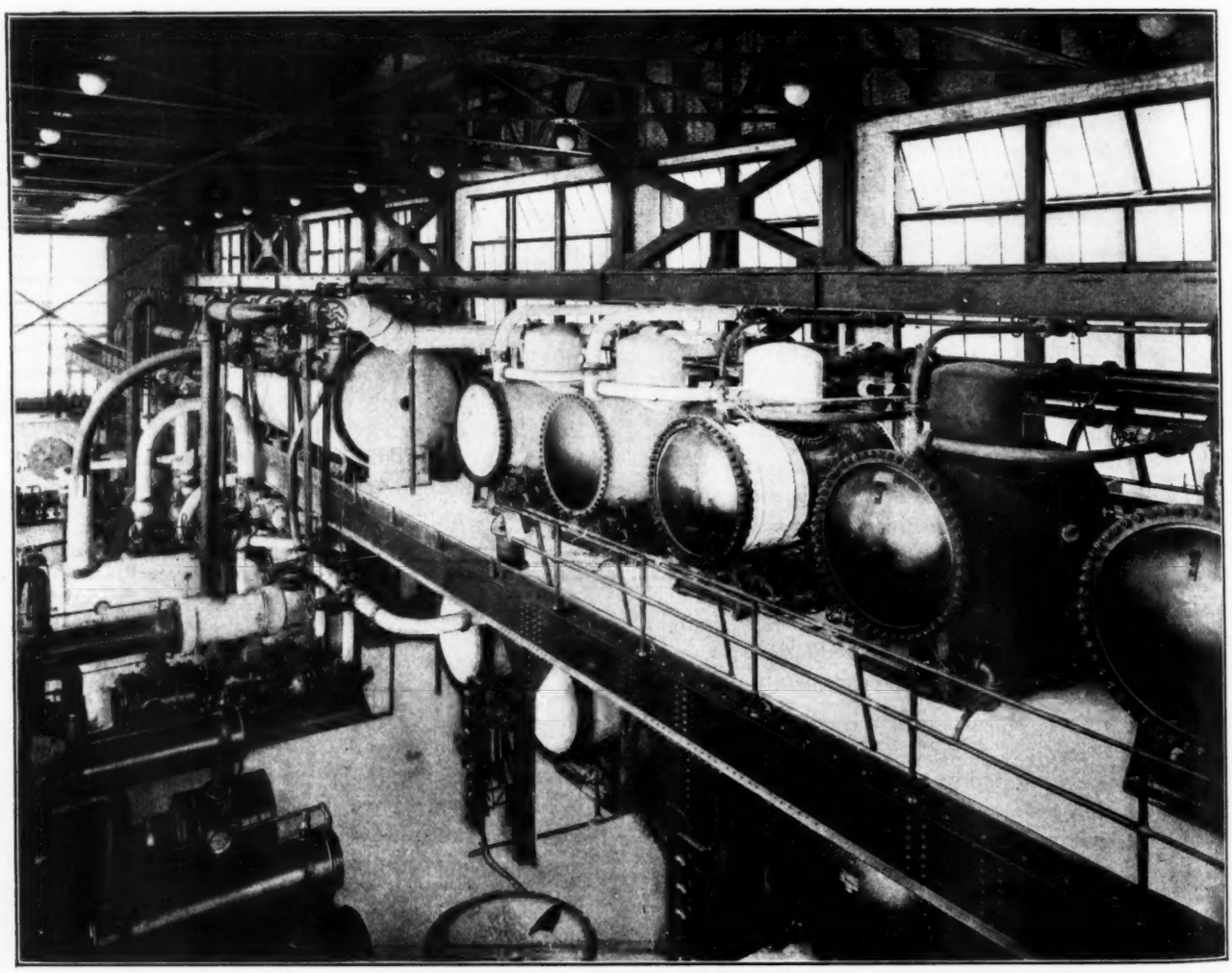


FIG. 1. TWO-EFFECT EVAPORATOR SYSTEM IN ITS PRESENT STATE OF COMPLETION

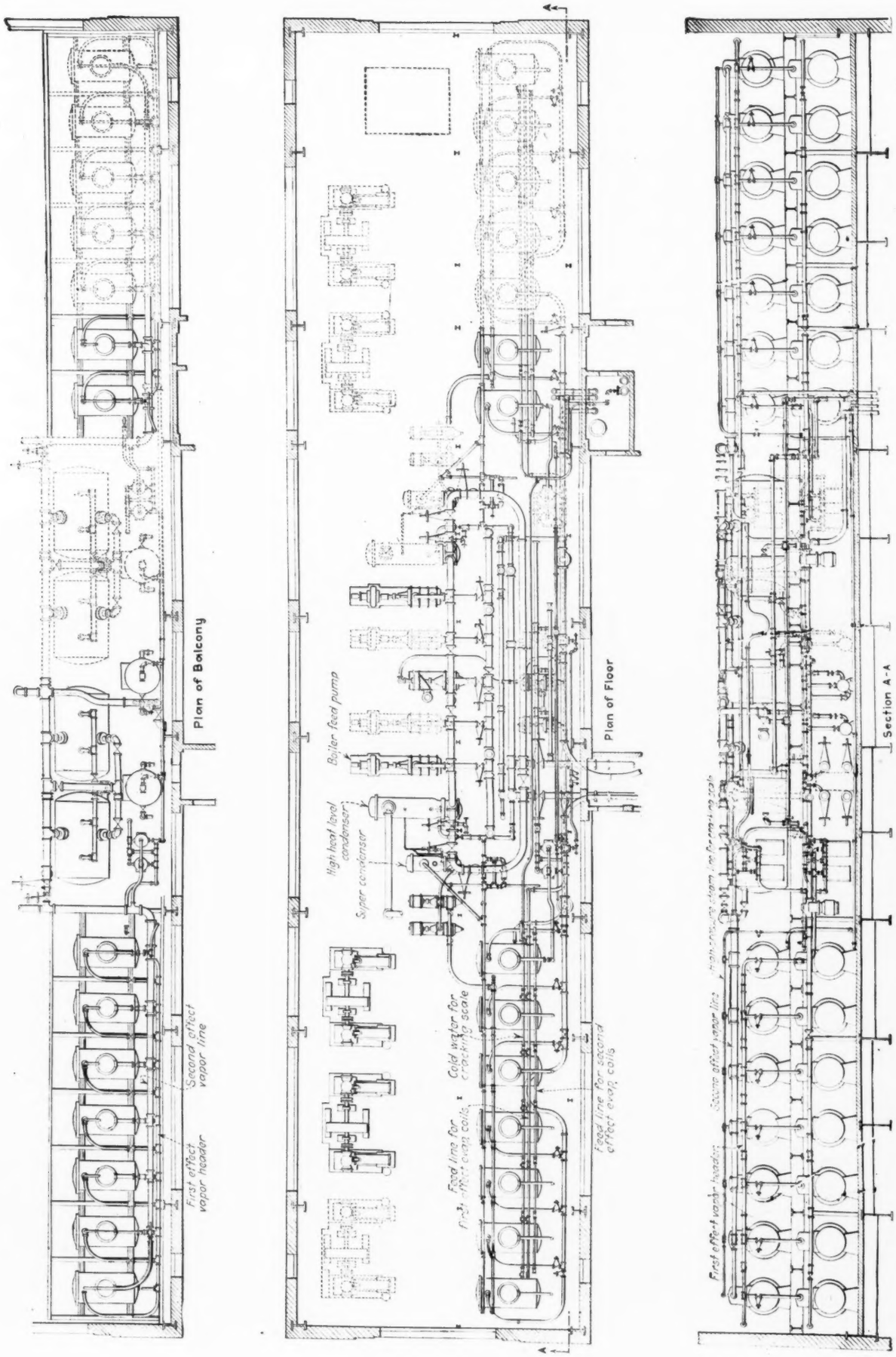

Plan of Balcony
First effect vapor header
Second effect vapor line
Plan of Floor
Boiler feed pump
High heat level condenser
Super condenser
Cold water for cracking scale
Feed line for first effect evap. coils
Feed line for second effect evap. coils
Section A-A

FIG. 2. GENERAL LAYOUT OF BOILER FEED-EVAPORATOR PLANT FOR EIGHT BOILERS

Before describing the character of evaporator apparatus as applied to the new blast-furnace installation, a few explanatory remarks may be of some assistance. The usual arrangement of incorporating evaporators is somewhat along the lines of a live-steam heater, as follows: Boiler steam is used as the heating means in the evaporator coils. The impure raw water is fed into the evaporator shell. In this shell pure vapor is produced and sent to the boiler-feed heater. The evaporator coil drains similarly are returned to the boiler-feed heater or directly to the boiler, as may be desired. So it will be noticed that in the process of evaporation, distilled makeup in a measure may be said to be the byproduct of a live-steam boiler-feed heater. Conversely, it will be seen that considering the system purely as an evaporator system, the over-all thermal efficiency is high, inasmuch as substantially all the heat devoted to evaporation is returned to the boiler system.

Two-Effect High-Heat-Level System

At the plant under discussion the installation is known as a two-effect high-heat-level system. In its present stage of completion it is shown in Fig. 1, consisting of nine first-effect and nine second-effect evaporators, with the accompanying heater and condenser equipment. Fig. 2 shows the layout of the system as planned for the eight boilers, the addition required being five more sets of evaporators indicated as future units by the dotted outlines in the drawing. Operation of the system may be traced more readily from the diagram of the system given in Fig. 3, which is based on the following early power-plant conditions: Boiler evaporation, 284,600 lb. net per hour; boiler steam, 200 lb. gage, 200 deg. of superheat; turbine condensate, 200,400 lb. per hour at 90 deg. F.; auxiliary exhaust steam, 4,200 lb. per hour at atmospheric pressure; distilled makeup, 80,000 lb. per hour net; raw water, from River Rouge, 80 deg. F. maximum.

As the output of the plant is later increased to full capacity, the various quantities listed will increase in substantially the proportions shown, at which time the distilled makeup will be in the region of 150,000 lb. an hour. It will be noticed from the figures that the boiler makeup is approximately 28 per cent of the boiler evaporation, due, as previously stated, to the large amount of boiler steam devoted to process, which cannot be suitably recovered.

The major units of the evaporator system, as it now stands, are nine first-effect evaporators and nine second-effect evaporators of the self-scaling type, shown in Figs. 4 and 5; two evaporator-feed open heaters of the circular pressure type, shown in Fig. 6; four-coil-type heat exchangers, as shown in Fig. 7, two of these serving as secondary heaters for the feed to each effect of the evaporator system; two high-heat-level condensers (that is, secondary closed-type boiler-feed heaters) as shown in Fig. 8, and one cast-steel desuperheater, as shown in Fig. 9.

Preheats the Evaporator Feed

In the diagram, Fig. 3, the nine evaporators for each effect are for simplicity shown as a single evaporator, as they all operate in multiple. The evaporator-feed open heaters are shown as a single heater, and the secondary-coil-type evaporator-feed heaters are omitted in the cut for the more ready understanding of the diagram. The function is simply to further preheat the evaporator feed by a portion of the vapor and thereby lessen the amount of live steam devoted to evaporation. The various figures of the diagram are approximate, and they will vary in harmony with the general power-plant requirements. The quantities shown are expressed in pounds per hour. Raw water from the River Rouge is shown to enter the evaporator-feed open heater at a maximum temperature of 80 deg., wherein it is preheated to the region of 210 deg. F. The heating means in part is radojet exhaust and for the remainder a portion of the evaporator from the second-effect evaporator vapor line. The evaporator feed is pumped through parallel piping directly to the first- and second-effect evaporator shells, the water levels in the shells being controlled by special automatic float-feed devices.

Boiler steam at 200 lb. gage and 200 deg. of superheat is shown to be lowered by a reducing valve to 185 lb. and desuperheated by the device indicated, so that the first-effect evaporator coils are supplied with dry and saturated steam at 185 lb. gage.

In the first-effect evaporators pure vapor is distilled (substantially one-half of the gross vapor), and this

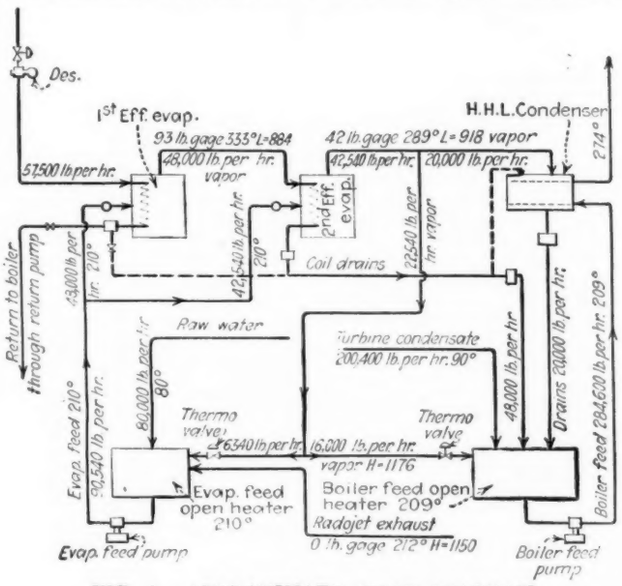
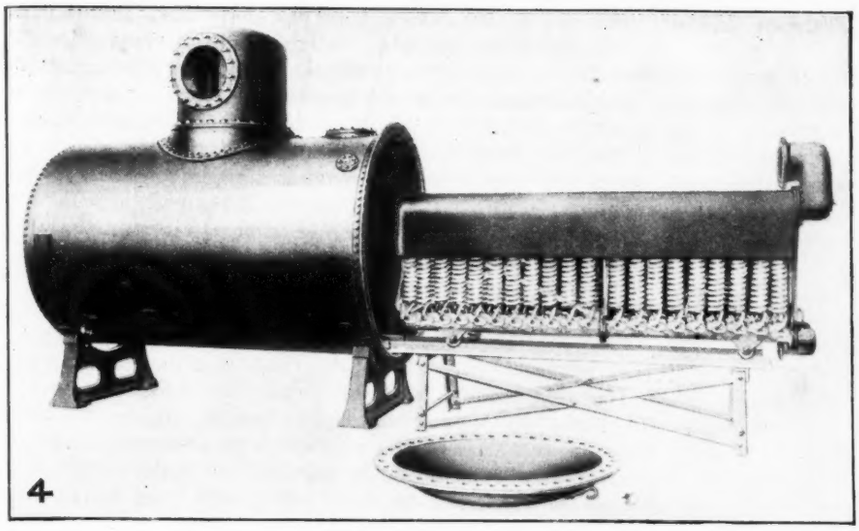

Des.
1st Eff. evap.
93 lb. gage 333°L=884
H.H.L. Condenser
42 lb. gage 289°L=918 vapor
274°
57500 lb per hr.
48,000 lb. per hr. vapor
42,540 lb per hr.
20,000 lb. per hr.
2nd Eff. evap.
42,540 lb. per hr. vapor
Coil drains
22,540 lb. per hr vapor
Return to boiler through return pump
33000 lb per hr. 210°
42,540 lb. per hr. 210°
Raw water
Turbine condensate 200,400 lb. per hr. 90°
80,000 lb. per hr. 80°
48,000 lb. per hr.
Drains 20000 lb. per hr. 209°
Evap. feed 210° 90,540 lb. per hr.
Thermo valve
6340 lb. per hr.
16,000 lb. per hr. vapor H=1176
Thermo valve
Evap. feed open heater 210°
Boiler feed open heater 209°
Radojet exhaust
0 lb. gage 212° H=1150
Boiler feed 284,600 lb. per hr. 209°
Evap. feed pump
Boiler feed pump

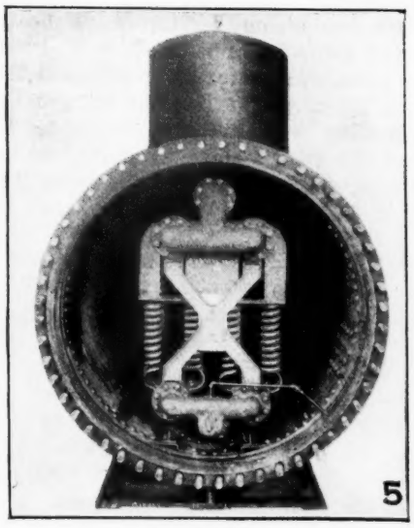
FIG. 3. APPROXIMATE HEAT DIAGRAM OF EVAPORATOR PLANT

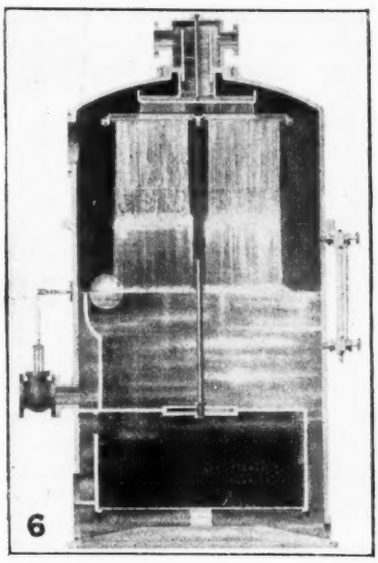
serves as the heating means in the coils of the second-effect evaporators. The coil drains from the first effect are trapped and pumped directly into the boiler-feed system on the discharge side of the boiler-feed pumps.

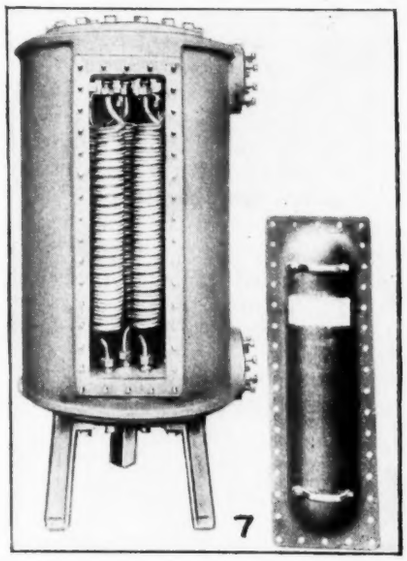
From the second effect the coil drains are passed to the boiler-feed open heater. The vapor (substantially one-half of the gross evaporation) is condensed partly in the high-heat-level condenser, partly in the evaporator-feed heater and the remainder in the boiler-feed open heater. The portion of the second-effect vapor condensed in the high-heat-level condenser gives up its latent heat to the boiler feed, increasing it in temperature from 209 deg., upon leaving the boiler-feed open heater, to 274 deg. The drains from this condenser and the remainder of the distilled makeup are returned directly to the boiler-feed open heater wherein they are mixed with the turbine condensate.

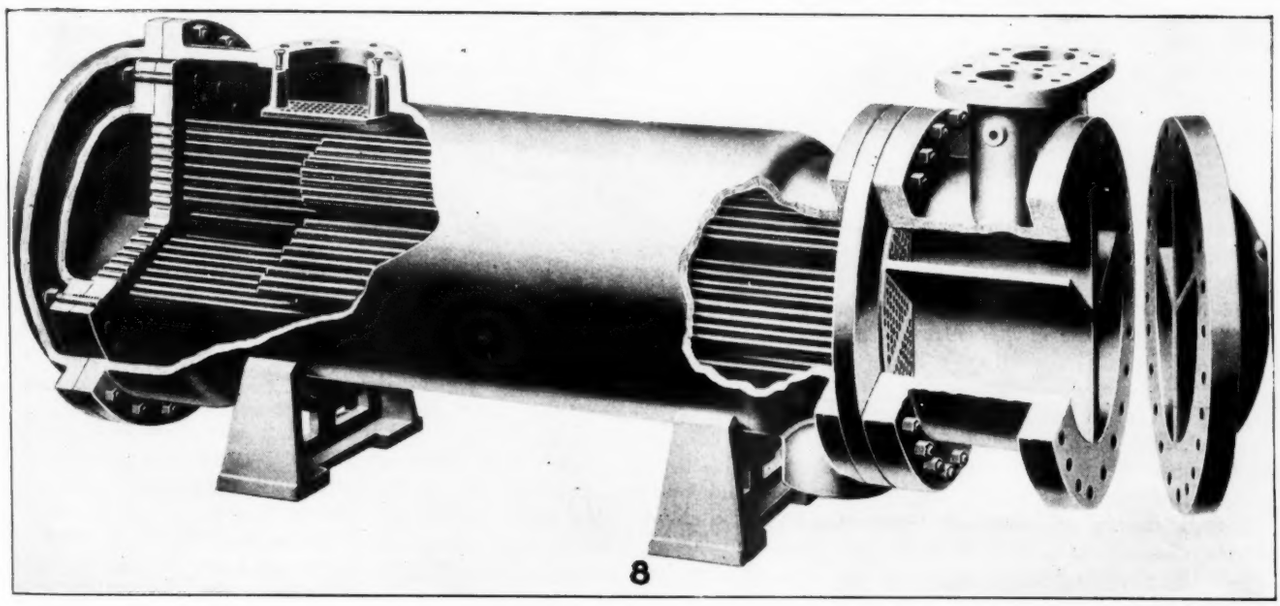
It will be noticed that the gross vapor produced by the evaporators is 90,540 lb., which is 10,540 lb. greater than the net makeup, as the evaporators must produce sufficient vapor to pay back to the system the low-











FIGS. 4 TO 8. SHOWING DETAILS OF EVAPORATOR, OPEN HEATER, SECONDARY HEATER AND HIGH-HEAT-LEVEL CONDENSER

Fig. 4—Self-Scaling Evaporator with Coil Elements Pulled Out of Shell. Fig. 5—End View of Evaporator with Cover Removed. Fig. 6—Massillon Evaporator Open Heater. Fig. 7—Coil-TypeSecondary Heater of Evaporator System. Fig. 8—High-Heat-Level Condenser.

pressure steam serving as a heating means in the evaporator-feed open heater.

Each evaporator is provided with a coil drain trap for the purpose of holding the pressure in the coils, but allowing the condensed vapor to be returned to the boiler-feed system. Similarly, the high-heat-level condenser is provided with a trap so that the entire latent

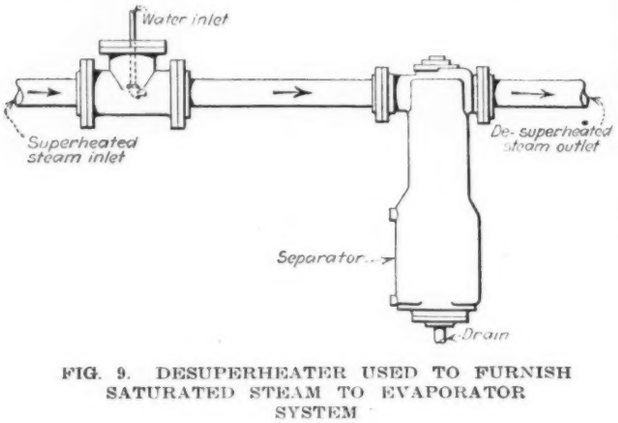


FIG. 9. DESUPERHEATER USED TO FURNISH SATURATED STEAM TO EVAPORATOR SYSTEM

heat of the second-effect vapor will be absorbed by the boiler feed, and only the condensed hot drains will be passed to the boiler-feed open heater.

Thermo valves are shown in the branch lines of the second-effect vapor, respectively passing to the evaporator-feed open heater and the boiler-feed open heater. These permit of full heating in the units referred to and at the same time maintain the desired operating pressure in the second-effect vapor line.

Flexibility in the relegation of heat returns to the boiler-feed open heater is afforded as indicated by the dotted lines; that is, the first-effect coil drains (hot water at about 380 deg.) can be passed to the boiler-feed open heater instead of pumped directly to the boiler. The dotted line shown as passing from the second-effect coil drains to the high-heat-level condenser may be so controlled as to allow a portion or all of the flash from the coil drains to be condensed in the high-heat-level condenser, or if desired, the entire heat of the second-effect coil drains (at a temperature of about 330 deg.) can be passed directly to the boiler-feed open heater.

It should be noticed that these alternate connections are for the provision of regulation beyond the normal intention of the system, for of itself the evaporator system is automatic through the functioning of the high-heat-level condenser.

If the demand for distilled makeup is lessened by virtue of the boiler evaporation lessening, with a consequent dimunition in the boiler feed, the high-heat-level condenser, which essentially is simply a closed type of high-pressure boiler-feed heater, will have less water to heat and, therefore, less evaporator vapor can be condensed. This would mean that the second-effect evaporator vapor, in attempting to enter the condenser, would be backed up to a higher pressure than indicated in the diagram, and this in turn would cause backing up of the pressure in the vapor of the first-effect evaporators. This would mean a lesser working-temperature difference from the evaporators, and would automatically reduce their output to harmonize with the quantity of boiler feed flowing through the high-heat-level condenser. It should be explained in this regard that the evaporators act simply along the lines of general heat exchangers, so that their output varies directly with the temperature difference between the vapor in the coils and the liquid in the shells.

It will be noticed from the foregoing description that the evaporator system is of the closed type, so that the heat devoted to evaporation is returned to the boilers, with the exception of the small amount of radiation through the lagging of the units and the piping, and the evaporator blowdown at the time of cracking scale from the evaporator coils.

Impurities in the raw water in part are deposited in the outer surfaces of the evaporator heating coils and in part stay in the solution in the evaporator shells. The elimination of these impurities from the evaporators is taken care of by "scale cracking." The process consists of closing the steam line to the evaporator coils, blowing down the content of the evaporator shell, filling the evaporator shell with cool water and then suddenly admitting high-pressure steam to the evaporator coils. The blowing down of the shell carries off the impurities still in solution. The introduction of cool water to the shell partly cracks the scale from the

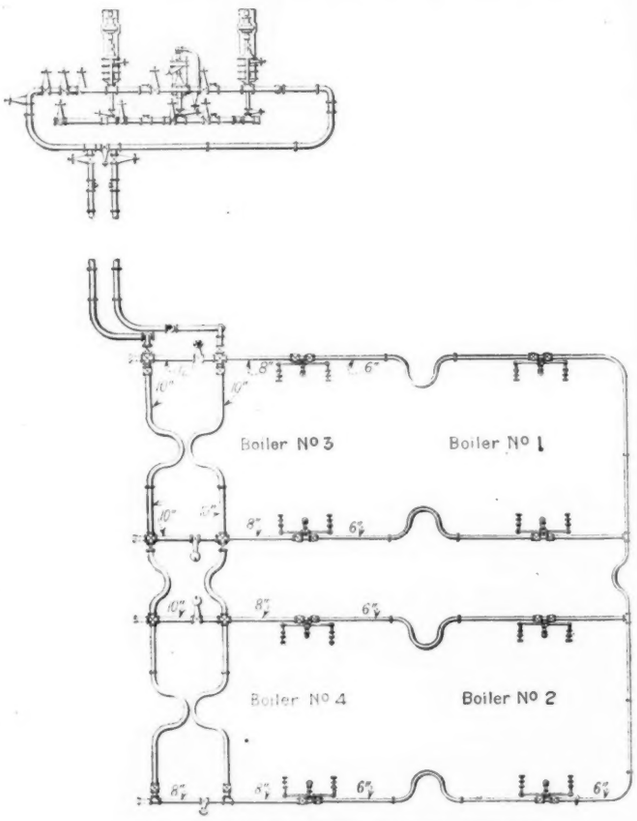


FIG. 10. BOILER-FEED-WATER PIPING

evaporator coils, and the sudden admission of live steam to the coils gives an abrupt tremendous temperature difference which, by virtue of expanding the tube section and slightly distorting the helical coil, removes the scale. This scale drops to the bottom of the evaporator shell and is discharged from the shell during the next cracking period. The time consumed for the scale cracking is but a few minutes and depends principally on the time required for filling the evaporator shell, which in turn is determined by the size of the evaporator feed line installed.

It will perhaps be interesting to follow the functioning of the desuperheater, shown in Fig. 9. This device is composed of a water-spray line and a cast-steel separator. The water-spray line is taken from the boiler feed, first, because it is pure water, and secondly, because no pump is required, as the boiler-feed line is at a greater pressure than the boiler drum. The spray water is absorbed by the steam in the process of extracting the superheat, with the result that the steam is changed to the saturated condition by the addition of this water. The spray is set for full-load conditions, and the function of the separator is to relieve the steam to the evaporator coils from excess water at lighter loads. There is no heat loss through this system other than radiation, for the spray water may be described as circulating through the evaporator system back to the boiler feed. The excess spray water at light load is returned to the boiler-feed open heater.

Referring back to the evaporators, the design shown in Figs. 4 and 5 is of the high-pressure type, with a shell working pressure of 125 lb. and coils and manifolds built for a working pressure of 250 lb. gage. The heating element is designed to pull out to facilitate inspection. The coils are attached to the upper and lower manifolds by special cone-seat mechanical connections, so that they are interchangeable and easily removed. The enveloping baffle over the tops of the helical coils prevents priming in that the vapor rising from the coils passes downward and thence upward through the water level. The evaporator vapor is further protected by a static centrifugal ringer incorporated in the vapor dome.

High-Heat-Level Condensers

The high-heat-level condensers, Fig. 8, which serve as secondary boiler-feed heaters, are designed for the maximum shell pressure that will be encountered in the varied operation of the evaporator system, and the water passages are built for a working pressure of 325 lb. gage. The illustration shows the strong construction and the multipass arrangement for the condensing water, which is boiler feed from the large open-plant heaters.

Having given the features of the evaporating makeup system, we may now trace the boiler-feed water. All condensate returns are brought back to a hotwell on the pipe-gallery floor and from there are pumped to either one of two open heaters, each having a capacity to raise the temperature of 600,000 lb. of water per hour from 160 to 212 deg. F. By the exhaust from the various steam-driven auxiliaries and turbine-driven pumps and the condensate from the evaporator coils, the temperature of the feed is raised from approximately 90 deg. to 209 deg. F. From the heaters the water flows by gravity to the feed pumps (of which there are three, any one being capable of supplying the four boilers) and is pumped through the high-heat-level condensers of the evaporator system to a ring system serving the boilers, the temperature in the condensers being increased to 274 deg., depending of course, upon the load conditions.

The three pumps are connected in parallel to a ring system of piping which taps to both sides of a loop around the boilers, with intermediate lines in the central aisle, so that both lower drums of each unit may be fed. These connections give more than one path for the water, so that disaster to any particular section of the line will not affect the continuity of the supply. A flow meter in each leg of the ring records the feed on its way to the boilers and also the temperature of the water. An individual feed-water regulator at each boiler controls the supply.

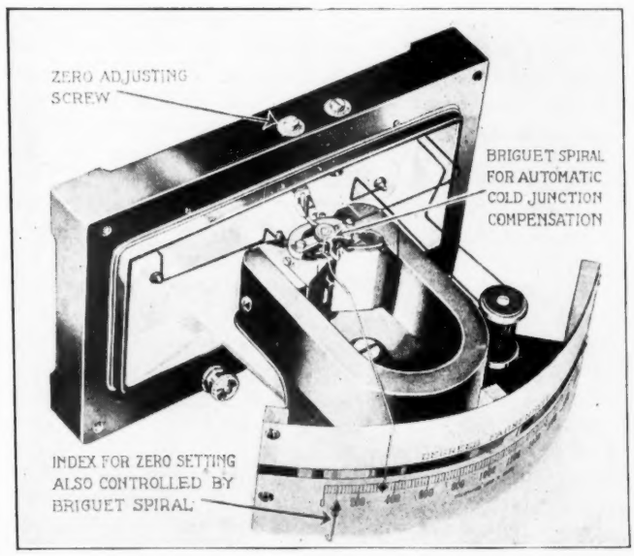
From the regulator there are two feeds into each lower drum of the two boiler elements. They discharge into a perforated header running lengthwise of the drum and located in a compartment partitioned off from the rest of the drum and separating the last four rows of tubes in the third pass from the general circulation. The feed water enters this space and passing slowly upward through the four rows of tubes, reaches the upper drum and enters into the general circulation. In case the water is not as pure as it should be, the scale-forming matter will precipitate in the tubes, settle into the inclosed portion of the drum and be kept out of the general circulation.

To each compartment of the drum there are six 2-in. blowoff connections which discharge into a 4-in. main running across the boiler front and dripping to a header on the pipe-gallery floor through which the water reaches a blowoff tank and eventually escapes to the sewer.

[*For much of the information contained in this article, we are indebted to Stanley Brown, of the Griscom-Russell Co., whose equipment is installed in the plant.—Editor.*]

New Brown Cold Junction Compensated Pyrometer

A new thermo-electric pyrometer, which is automatically compensated in the instrument for changes in cold junction temperatures and which includes means of setting the pointer of the instrument to zero in the usual manner, enables the user to set the instrument to zero, provided the zero has shifted owing to jars in transportation or from continual service.


ZERO ADJUSTING SCREW
BRIGUET SPIRAL FOR AUTOMATIC COLD JUNCTION COMPENSATION
INDEX FOR ZERO SETTING ALSO CONTROLLED BY BRIGUET SPIRAL

COLD-JUNCTION COMPENSATED PYROMETER

In the new Brown pyrometer, which is manufactured by the Brown Instrument Co., Philadelphia, Pa., compensated for cold junction changes in temperature, it is only necessary to bring the compensating or extension leads from the thermocouple to the instrument.

After mounting the instrument, the pointer is set by the zero adjuster to correspond with the index on the scale. If the values for a thermocouple have been determined, based on a cold junction of 75 deg. F., the index will indicate 75 deg. F. provided the instrument is subject to this surrounding temperature. If the instrument pointer does not correspond with this index, it is set accordingly. When the temperature surrounding the instrument and the cold junction of the end of the compensating leads at the instrument rises to 90 deg. F., the index automatically rises to 90 deg. F., and the Briquet spiral attached to the instrument pointer causes it to move up to 90 deg. F., automatically adjusting for the temperature of the cold junction of the thermocouple.

Any number of thermocouples with their extension or compensating leads can be brought to the one instrument having this automatic compensation. Likewise, recording instruments can be equipped with this automatic compensation and means for setting the pointer to zero.

"Natural Steam" Plant Proposed in California

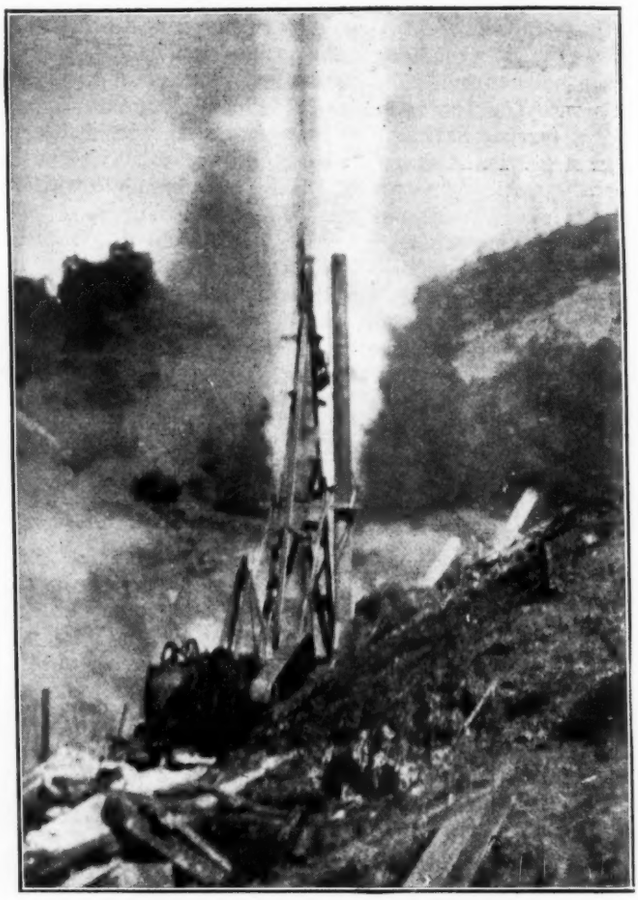
Preliminary work is well under way at a point known as The Geysers, about 75 miles north of San Francisco, Cal., on a project for developing power with the steam that is continually escaping from the earth there. The development proposed would be similar to that at the Lardorello installation in Italy,[1] which has been using heat from the earth to operate a steam-turbine plant for a number of years. Proponents of the California project are advising with the engineers who installed the Italian plant, particularly with reference to means of eliminating corrosive gases.

Preliminary work at The Geysers has included the driving of several wells to determine temperatures, pressure and quantities. At first oil-well casings were used, but these were found to buckle too easily under the high temperatures encountered. A casing now being driven is being sunk by oil-well methods, using a special tool-steel drill followed by a casing of 12-in. standard threaded pipe weighing 45 lb. per ft. This casing has reached a depth of 99 ft. Of this the first 65 ft. is through an earth overburden, below which is about 30 ft. of ashes overlying hard sandstone.

For the first 16 ft. a 30-in. casing was used, into which were tapped 12-in. pipes to lead the heat away from the drill rig on the surface. Four of these 12-in. vent pipes were used, three projecting well above ground to give the advantage of draft, and the fourth entering from a lower level to serve as an intake. Even with this arrangement and with the drill rig proper 12 ft. back from the top of the casing, the heat of escaping vapors is high enough to hinder the work materially. Steam explosions that eject ashes and rock violently, sometimes to a height of 300 ft., occur from time to time.

In the district being explored, temperatures ranging up to 350 deg. F. are found in many places at the surface over an area about one-half mile square, and it is believed that these temperatures increase very materially below ground. With these temperatures water that becomes imprisoned beneath the earth's surface is transformed into steam with explosive violence. With the casing open and clear at the top, water put down the well in just the right quantities comes back in the form of steam shooting out under high pressure.

Hydrogen sulphide and other gases are encountered at The Geysers, but it is claimed that corrosion occurs only when metal is exposed to the gases in the open air. That is, the interiors of pipes carrying the vapor and pipes entirely buried in the earth are not affected. Both gaseous and liquid samples have been sent to Italy for analysis by the same methods applied at the Lardorello plant. In the Italian development drillings were made to depths up to 495 ft. to secure the temperatures required for the turbines, while at The Geysers the same temperatures are said to be found at depths of about 75 ft. The original method at the Italian plant was to use the steam as a source of heat for evaporating water, which in turn was used in the turbine. Based on later experience, however, the plant at The Geysers is to be arranged to use a gas-filtering or purifying process so the live steam from the vents can be used directly in turbines.



DRIVING CASING AROUND GEYSER

The Black streak passing vertically upward through derrick is ashes and rock. Vertical casing alongside derricks and two gun-like tubes to right are vents to carry off heat.

The present plan is to install first a small plant developing 300 to 500 kw. with which to supply power for further exploration and construction work. It is proposed then to install a much larger plant, possibly about 20,000 kw.

The project is in charge of J. D. Grant, The Geysers to whom *Power* is indebted for the foregoing.

[1] See *Power*, Jan. 13 1920, and June 1, 1920.

Working Temperatures and Pressures in the Refrigeration Plant

By W. H. MOTZ

THE science of refrigeration deals with the process of cooling bodies or substances below the temperature of the surroundings by the extraction of heat from the body or substance in question. It follows that refrigeration is a thermal process in which temperatures are of primary importance. Now, one of the fundamental laws of physical nature states that heat always tends to flow or pass from a body or substance at a higher temperature to a body of lower temperature and will not pass from a low-temperature body to a high-temperature one. Thus, if it is desired to hold a cold-storage room at 25 deg. F., it is necessary to introduce into the room a material that has a lower temperature than the room itself. Hence, a pipe coil containing ammonia or any other refrigerant is placed in the room. The pressure is maintained in the coil so that the temperature of evaporization is below the desired room temperature. Then, due to the natural tendency already mentioned, the heat in the room tends to flow through the coil into the boiling ammonia. The total amount of heat that may be transferred under these conditions depends upon the mean temperature difference, the amount and arrangement of the cooling-coil surface, and the unit heat transfer coefficient of the coil surface. It is obvious that the mean temperature difference is of primary importance.

The magnitude of the temperature differences between the various elements of the refrigerating plants depends upon economic considerations, and, the cost of power, together with the cost of the pipe coil, determines, to a large extent, the magnitude of the temperature differences carried.

In general, it may be said that the larger amount of coil surface will produce more economical operating conditions, due to the fact that the suction pressure may be carried at a higher point. This is for the reason that with a large coil surface the temperature difference can be reduced. The suction pressure should be carried as high as possible and still maintain the desired temperatures. The principal advantage in using a high suction pressure is that less power is required per ton of refrigeration than with lower suction pressures. An additional advantage of higher suction is that the tonnage capacity of the compressor per cubic foot of displacement increases as the suction is increased since the ammonia weighs more per cubic foot.

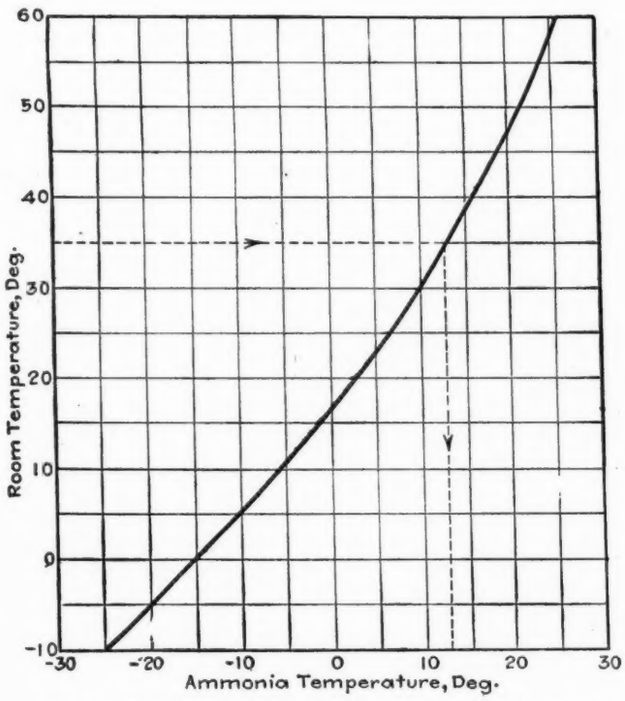


FIG. 1. TEMPERATURES WITH DIRECT EXPANSION

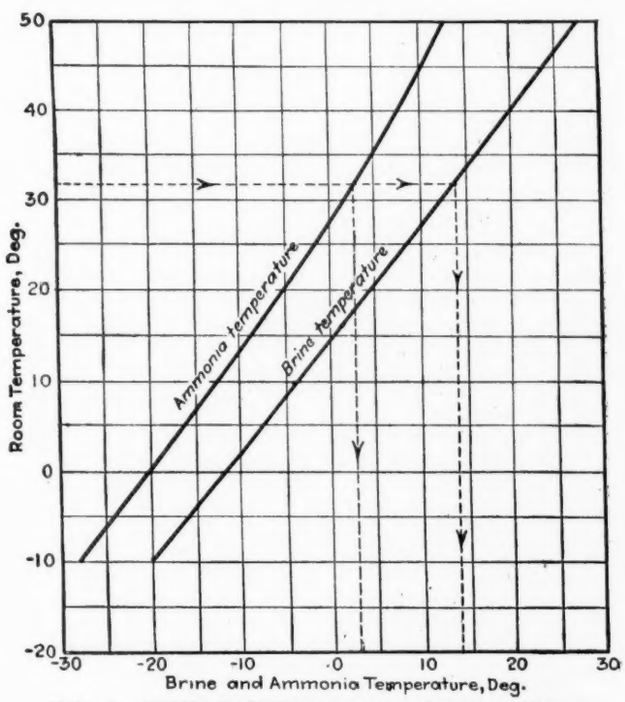


FIG. 2. TEMPERATURES WITH BRINE COOLING

In order to convey to the reader an idea of the magnitude of these temperature differences, Figs. 1 and 2 have been prepared. The chart in Fig. 1 indicates the relation between the temperature of cold-storage rooms and the temperature of the evaporating ammonia in the cooling coils. These temperature differences should be maintained in order to secure economical operation.

The following values, taken from Fig. 1, will indicate the variation of the temperature differences as the room temperature increases:

Room temperature deg. F	—10	0	10	20	30	40	50	60
Ammonia temperature, deg. F	—25	—15	—5	3	10	16	22	26
Temperature difference, deg. F	—15	15	15	17	20	24	28	34

In a similar manner Fig. 2 illustrates the relationship of the room temperatures, brine temperatures and

ammonia temperatures in a refrigerating plant in which the rooms are cooled by brine coils. In this type of plant the total temperature difference between the room and the ammonia is somewhat greater, due to the fact that the brine must be at a lower temperature than the room, and in turn the ammonia temperature must be below that of the brine in order to remove the heat.

The following tabulation will show the temperature differences which will promote efficient operation:

Room temperature, deg. F.	—10	0	10	20	30	40	50
Brine temperature, deg. F.	—20	—12	—4	4	12	20	28
Temperature difference, deg. F.	10	12	14	16	18	20	22
Room temperature, deg. F.	—10	0	10	20	30	40	50
Ammonia temperature, deg. F.	—28	—20	—13	—6	1	8	13
Temperature difference, deg. F.	18	20	23	26	29	32	37
Brine temperature, deg. F.	—10	0	10	20	30	40	50
Ammonia temperature, deg. F.	—18	—8	1	10	18	28	35
Temperature difference, deg. F.	8	8	9	10	12	12	15

By reference to Figs. 1 and 2 the temperature of the ammonia that will produce the desirable results may be ascertained. Then by reference to Fig. 3, which indicates the gage pressure of saturated ammonia vapor corresponding to various temperatures, the suction pressures that should be used may be obtained.

Suction Pressures and Temperatures

Since it is the province of refrigeration to deal primarily with temperatures, it is obvious that efficient methods of temperature indications must be employed in order to accomplish the proper results.

In the first place the thermometers should be accurate temperature indicators. In the second place they should be installed properly. To secure intelligent readings at the proper intervals, the thermometers should be placed in accessible places.

In case of the suction side of the system the thermometers are best installed near the coil ends or, preferably, in the suction connection near the compressor. Of course, the type and size of plant governs the amount and kind of thermometers and gages that should be installed. Generally speaking, the capital invested in such instruments brings large returns.

Ordinarily, on suction connections to compressors a recording pressure gage, together with a thermometer, will afford excellent means of regulating the suction pressure. On the other hand, the advantages of having permanent records of pressures and temperatures in the form of charts from recording instruments are obvious.

The plant can be operated efficiently only when the knowledge of the conditions is accurate. After the temperature and pressure of the return vapor has been ascertained, the exact state of the refrigerant may be determined by consulting a table of the properties of the refrigerant. The chart in Fig. 3 gives the saturated temperature at various pressures; any temperature above this denotes superheat.

Furthermore, the actual regulating of the evaporating-coil pressure and temperature is obtained by the proper manipulation of the expansion valves. These valves should be regulated so that the suction gases will have only 5 to 10 degrees of superheat at the compressor. The ease of regulation largely depends upon the design of the piping system, the installation of traps and separators, etc.

When the vapors come to the compressor in the saturated state, the largest weight of refrigerant will be handled and thus the larger amount of refrigeration will be produced. In the case that horizontal compressors are used, the frost should be allowed to come back to the compressor manifold. Likewise, in plants where the suction pressure is quite low, it may be found advisable to allow a small amount of liquid to enter the compressor for the purpose of preventing high temperatures at the end of compression.

In a similar manner the use of the thermometers facilitates the operation of vertical compressors, since in this type of compressor it is not so advisable to allow liquid refrigerant to enter the cylinder. This is due to the fact that the vertical machine does not handle the moist vapor as efficiently as the horizontal type. The use of thermometers will show the proper degrees of superheat for efficient operation.

The reader is able to recall, no doubt, many operating problems that may be readily solved by reference to accurate temperature indications. Where the suction gas is many degrees above the temperature corresponding to pressure, several causes may be suspected, such as leakage of compressor valves, lack of ammonia, etc.

Discharge Temperatures and Pressures

The proper regulation of the discharge temperature is an important consideration in the successful operation of the refrigeration plant. If the temperatures at the end of compression are allowed to became fairly high, the ammonia or other refrigerant may tend to disintegrate into the elementary constituents. This leads to the presence of non-condensable or permanent gases in the system. A far more prevalent result is the disintegrating of the lubricating oil.

The temperature of the gases at the end of compression depends upon the ratio of the absolute condenser pressure to the absolute suction pressure (gage pressure plus 15 lb.), or in other words, the ratio of compression, and upon the degree of superheat of the suction gases. The degrees of superheat or the condition of the suction vapors may be regulated by means of proper adjustment of the expansion valves.

The variation of the temperature of the refrigerant at the end of compression will depend on the ratio of compression and the characteristic law of compression of the refrigerant. The temperature of ammonia gas at the end of compression may be determined by the following formula:

$$t_d = [(t_s + 459.6) \times X] - 459.6$$

where

t_d = Temperature of discharge gases, deg. F.;

t_s = Temperature of suction vapor, deg. F.;

459.6 = A constant (absolute temperature at zero Fahrenheit);

X = A variable quantity depending upon the ratio of compression.

To enable the engineer to avoid the use of mathematics as much as possible, the values of X for various pressure ratios have been computed and are as follows:

Ratio of Compression	Variable Quantity X	Ratio of Compression	Variable Quantity X
2.0	1.174	9.0	1.660
2.5	1.245	9.5	1.682
3.0	1.285	10.0	1.702
3.5	1.335	10.5	1.722
4.0	1.377	11.0	1.742
4.5	1.425	11.5	1.758
5.0	1.450	12.0	1.773
5.5	1.483	12.5	1.792
6.0	1.512	13.0	1.809
6.5	1.541	13.5	1.826
7.0	1.568	14.0	1.841
7.5	1.596	14.5	1.856
8.0	1.616	15.0	1.870
8.5	1.639		

The foregoing formula holds true, provided the ammonia vapor contains no ammonia liquid at the begin-

ning of compression; that is, it is just dry and saturated or it may have a few degrees of superheat.

To illustrate the foregoing formula in a practical manner, it will be assumed that the suction and condenser pressures are 15 and 165 lb. gage respectively. The absolute pressures, found by adding 15 lb. to these gage pressures, would be 30 and 180 lb. approximately. The ratio of compression is then equal to $180 \div 30 = 6$. From the table the value of X will be found to be 1.512, and from a table of properties of ammonia the temperature at 30 lb. abs. pressure will be found to be equal to 0 deg. F.

In the case of no superheating of the ammonia vapor along the suction line, 0 deg. would be the value for t_s in the formula. These values may be substituted in the formula as follows:

$t_d = [(0 + 459.6) \times 1.512] - 459.6$, thus $t_d = 235.3$ deg.

This is the theoretical discharge temperature, and the actual temperature may be a few degrees lower owing to loss of heat to the walls of the compressor cylinder.

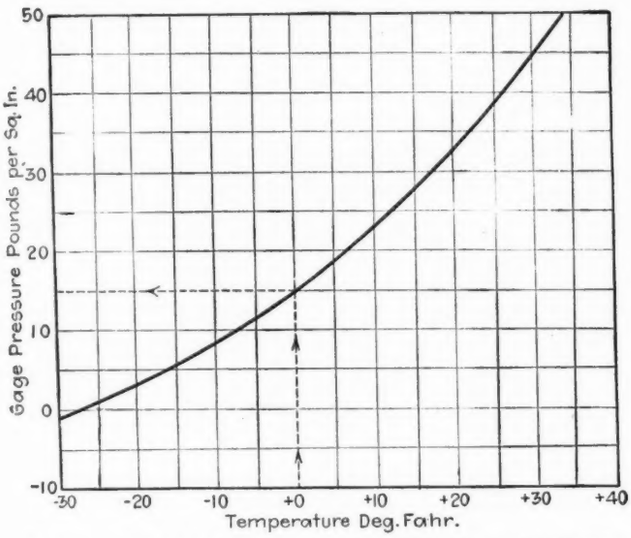


FIG. 3. TEMPERATURE AND PRESSURE RELATION OF AMMONIA

The forgoing calculation will show the operating engineer just about what temperature he should expect under a given set of conditions.

Under ordinary conditions it is advisable to provide means of ascertaining the temperature of the discharge gases. Indicating or recording thermometers may be installed. However, it should be evident that the operation of the compressor is determined primarily by the temperature and pressure of the suction vapor, and that the discharge temperature will take care of itself if the conditions are what they should be on the suction side of the machine.

The thermometer in the discharge main will be found useful in the event that the thermometer in the suction main is broken or out of order, since it would be possible, by reference to the engine-room log, to determine just what the suction temperature should be in reference to the discharge temperature.

To sum up the considerations of the temperature and pressures of the suction and discharge gases, the following statements may be made: The suction pressure should be carried as high as possible, maintaining at the same time the desired temperatures. The suction vapor should enter the compressor as near as possible to the saturation temperature corresponding to the pressure, without increasing the danger of getting liquid ammonia into the compressor cylinder; that is, the suction vapor should be only slightly superheated. The discharge pressure should be kept as low as possible, giving especial attention to the quantity of water available and the amount of condenser surface. The discharge temperature should be kept as low as possible.

The operating engineer must be provided with means of ascertainting the temperature and pressures of the refrigerant as it passes through the compressor. He will then be in a more advantageous position to operate the compressor in the most efficient manner.

Other Uses of Thermometers

The use of thermometers is essential to the efficient operation of ammonia condensers. The performance of the various sections should be controlled by observing the temperature of the water leaving the various coils. These temperatures can easily be determined by installing suitable thermometers.

The temperature should be approximately the same for all the coils to operate evenly. By proper temperature indications and manipulation of valves it is an easy matter to operate the various types of condensers. Of course it is well to employ thermometers to indicate the temperature of the water into and out of the condenser.

The same general considerations apply to the operation of brine coolers. In the event that more than one cooler is employed, thermometers should be located in the brine outlets of each coil or cooler. This facilitates the dividing of the work evenly among the coolers. Of course thermometers should be installed in the main brine lines to indicate the average cooling of the total amount of brine.

It is well to use recording thermometers for determining the temperature range of the water through the condensers and the brine through the brine coolers. These furnish permanent records of the daily operating conditions.

Since the temperature of the liquid ammonia just before the expansion valve has a direct bearing upon the refrigerating effect of the ammonia in the evaporating coils, it is evident that a thermometer should be installed in the liquid at a point just before the expansion valve. The temperature at this point has not only a bearing on the refrigerating effect, but it is also, a factor in determining the advisability of aftercooling the liquid ammonia.

The operating engineer should study his own individual plant with the view of determining the most economical working temperatures and pressures. He should then adopt efficient means of ascertaining and maintaining these temperatures and pressures.

In the Aug. 2, 1921, issue of *Power* a general description was given of the investigation then being carried on by the Bureau of Mines on the Trent process. It may be recalled that in this process low-grade powdered coal is beaten up in a mixture of oil and water, with the result that the oil and good coal separate out in the form of an "amalgam." It is reported that further experiments with this process have resulted in entirely unexpected developments. For example, it has been found that when the amalgam is subjected to distillation for gas-making, the amount of gas produced is double the total obtainable from the coal and the oil taken separately, and has a slightly higher heating value.

Fedeler Hot-Bearing Alarms

The two hot-bearing alarms illustrated herewith introduce the sense of smell in the one and the sense of sight as a medium to find out when the bearing is becoming too warm in the other. The hot-bearing alarm, Fig. 1, is a glass oil cup filled with a strong-smelling lubricating oil. The spout of this oil cup should reach into the bearing within $\frac{1}{16}$ in. of the shaft. The end of this spout is provided with a sulphur plug which prevents the oil from running out of the cup. This fusible plug can be provided to melt at a predetermined temperature, at from 150 to 300 deg. F. or more. If the bearing gets too hot, the fusible plug melts and the odor of the oil will call attention to the fact.

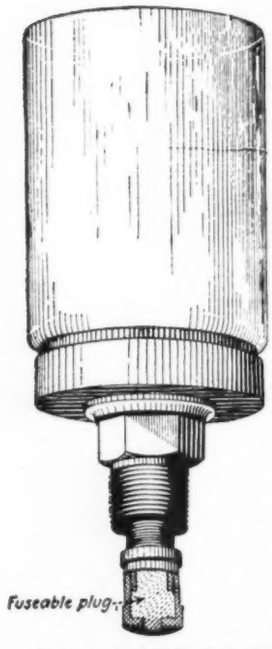


FIG. 1. HOT-BEARING ALARM WITH SCENTED OIL

The indicator, Fig. 2, shows when a bearing is or has been hot. It is merely a strip of steel or spring brass which is rolled up and thus held by a rivet of soft metal that melts at 190 deg. or more as the case may require. This roll is screwed to the outside of, say, a lineshaft bearing located in a dark place. and eliminates the necessity of frequent inspection.

The steel strip is painted with luminous paint on the inside so that when the bearing heats sufficiently the rivet holding the roll together melts and the spring

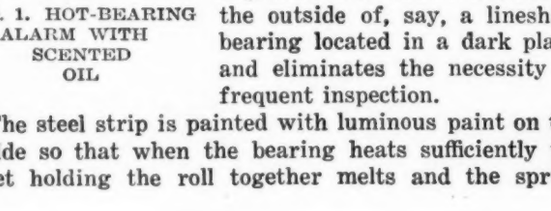


FIG. 2. LUMINOUS HOT-BEARING ALARM

unrolls and indicates that the bearing is hot, the luminous paint showing in the dark.

There is also a hot bearing fuse that is similar to the indicator, but the spring is shorter and has a dent in it so that when it moved back and forth it makes a sound like a cricket. It can be used on crankpins and crossheads and will notify the engineer by the sound when the part to which it is attached becomes too hot.

These three types of hot-bearing alarms—the lubricating oil, scented with an easily detected perfume, the luminous metal strip and the cricket-sounding alarm—should meet the requirements of most hot-bearing demands, and give the operator ample warning before serious damage is done.

These devices have been designed by J. H. Fedeler, 11 West Fortieth Street, New York City; patents pending.

Steel Belt Conveyor

When a belt conveyor is mentioned, it is natural to think of a canvas, balatta or rubber belt, because of their universal adoption. To speak of steel belt conveyors immediately brings one into a foreign field, and questions arise as to their utility, because they have not been generally used in this country.

The Sandviken Steel Works, of Sweden, about twelve years ago began to make a steel conveying belt. It is known as the "Sandvik" belt and is made from Swedish charcoal steel, cold-rolled, hardened and tempered. The belt has a tensile strength of 177,500 lb. per sq.in. Because of the methods of heat treatment, hardening and tempering, it has rust-resisting qualities.

FIG. 1. A 285-FT. STEEL BELT, 16 IN. WIDE AND 0.035 IN. THICK.

FIG. 2. RIVETED JOINTS OF BELT, BOTTOM SHOWING HOLDING OF RIVETS WHEN FLUSH WITH BELT SURFACE.

As the steel belt possesses transverse rigidity, it has a high capacity, because the edges, even with a one-sided load, do not yield in a downward direction.

The conveyor is designed in two ways—either with the conveying strand sliding on a wooden support, sometimes fitted with skirting boards, trough-like, the return strand being supported by idlers, or else both strands of the band are carried on rollers in the usual manner. This steel belt is cold-rolled in one-piece lengths up to 300 ft. Fig. 1 shows a belt 285 ft. in length, 16 in. wide and 0.035 in. thick, the total weight being about 550 lb. Such conveyor belts are ordinarily cold-rolled, not polished or treated in any way; hardened and tempered only. The working stress of the belt when it passes over a standard-size pulley is 28,000 to 30,000 lb. per sq.in. The joints are riveted, Fig. 2 showing such joints, one with full rivet heads, the other showing that even with the rivet heads worn smooth with the belt surface the countersunk portion will firmly hold the joint.

This belt is sold in this country by the Sandvik Steel Works American Agency, Tribune Building, New York City.

How to Find Voltage-Drop in Electric Circuits

A Chart From Which the Line Drop, Length of Circuit, Currents Values and Size of Conductors Can Be Determined Without Calculation

By EDGAR P. SLACK
Assistant Electrical Engineer, Underwriters Laboratories

A QUESTION to be considered in installing every electrical circuit is the size of wire to use. First of all, wires should be large enough to carry the current without overheating, following the allowable carrying capacities in the National Electrical Code and noting also that no circuit wire smaller than No. 14 B. & S. gage is permitted. For small currents and short lines this will generally determine the wire size to use. For large currents or long runs, while it is still necessary to provide the required carrying capacity, another factor enters which frequently necessitates even larger wires; that is, the allowable voltage drop.

There are no standard requirements for voltage drop, the amount allowed varying with different engineers and depending also on the nature of the load supplied. For incandescent lighting the allowable drop is frequently restricted to two volts, on account of the variation in illumination, resulting from even a slight voltage decrease. For motor work a drop of 10 per cent of the line voltage may be encountered, and motor manufacturers generally guarantee their machines to operate successfully at normal rated load with the impressed voltage reduced 10 per cent.

The size of wire corresponding to a given current, length of line and voltage drop can be computed by the following formula which applies to any two-wire direct-current curcuit:

$$Circ.mils = \frac{21 \times I \times L}{E_d} \qquad (1)$$

where circ.mils equal size of wire in circular mils, I equals current in amperes, L length of one line one way and E_d equal voltage drop. After the wire size necessary to satisfy the voltage-drop requirement has been determined, the carrying capacity of this wire should be checked, since a larger wire may be necessary to carry the current without excessive heating.

Suppose a line is to supply a load of 300 amperes at a point 1,000 ft. from the source, the voltage drop not to exceed 7 volts. By formula (1) the wire size will be $Circ.mils = \frac{21 \times 300 \times 1{,}000}{7}$, or 900,000. The table of carrying capacities shows that a cable of this size will carry 600 amperes, and as this carrying capacity is ample, 900,000 circ.mils is the wire size to use.

The accompanying "Voltage-Drop Chart" is intended to conveniently give the wire size corresponding to any ordinary current, length of line and voltage-drop. The directions on the chart show the method of use, but it is illustrated by the following examples. In the case already computed, where the current is 300 amperes, the load 1,000 ft. from the source (2,000 ft. to load and back) and allowable drop 7 volts, the wire size is found as follows:

Starting at the left-hand side of the chart, find the point of intersection of the 300-ampere line and the 2,000-ft. line. From this point follow horizontally across the chart until the 7-volt-drop line is reached. At this point the chart indicates a 900,000-circ.mil wire size, which agrees with the calculation. To find the approximate carrying capacity of this cable, with rubber insulation, a small circle will be noted near the end of the 900,000-circ.mil wire-size line, directly across the chart from which appears a corresponding circle on the 600-ampere line. The carrying capacity is therefore approximately 600 amperes, which also agrees with the value found in the foregoing.

If it were desired to find the voltage drop corresponding to a given current, length of line and conductor size, the formula would become:

$$E_d = \frac{21 \times I \times L}{Circ.\ mils} \qquad (2)$$

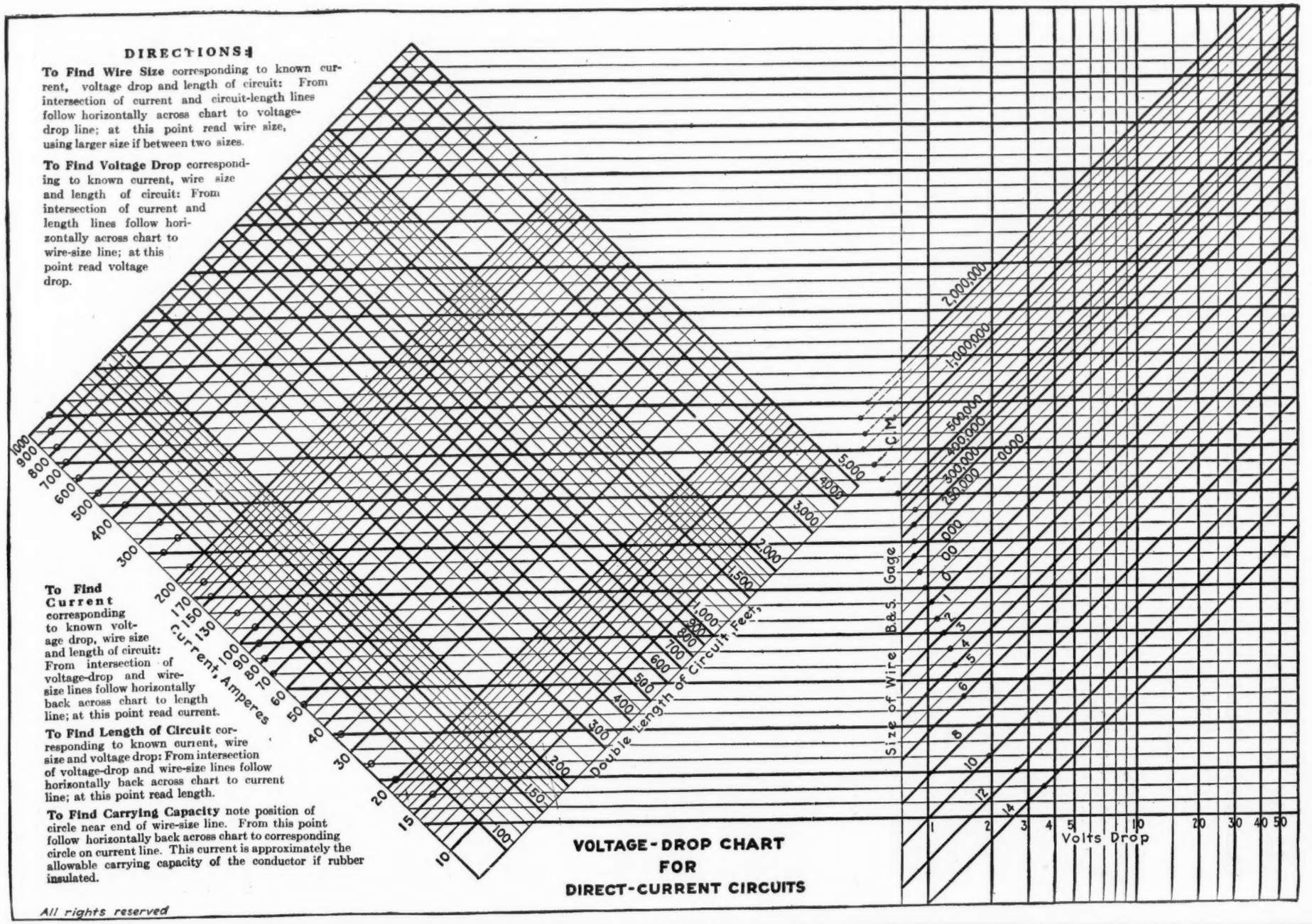
the symbols being the same as before. Here, again, the wire size should be such as to provide suitable carrying capacity.

Assume, for instance, a group of industrial heaters requiring 150 amperes, operating at the end of a 650-ft. line (1,300 ft. to the load and back) of No. 0000 wire (circ.mils = 211,600). By formula (2) the voltage drop is $E_d = \frac{21 \times 150 \times 650}{211{,}600}$, or 9.7 volts. The No. 0000 rubber-covered cable is found by the wire table to have a carrying capacity of 225 amperes. Solving the same problem by the chart: Find the intersection of the 150-ampere line with the 1,300-ft. line, and travel horizontally across the chart from this point until the No. 0000 wire-size line is reached. At this point the chart shows a voltage drop of about 9.7 volts, checking with the foregoing value. The approximate carrying capacity of the No. 0000 wire is indicated by the corresponding circles on the chart to be 200 amperes, which also checks approximately, the variation being on the safe side. The wire size is noted to be ample for the load current.

Again, to determine the current that can be transmitted by a circuit of a given size and length with a specified voltage drop, the formula becomes:

$$I = \frac{E_d \times circ.mils}{21 \times L} \qquad (3)$$

For example, a 1,000,000-circ.mil circuit is to be used to supply a load 475 ft. distant (950 ft. to load and back), with the voltage drop restricted to 5 volts. The allowable current is found by formula (3) to be $I = \frac{5 \times 1{,}000{,}000}{21 \times 475} = 500$ amperes. A 1,000,000-circ.mil rubber-covered cable has a carrying capacity of 650 amperes and is therefore suitable for the case in hand. Solving this problem by the chart, find the intersection of the 5-volt-drop line with the 1,000,000-circ.mil wire-size line and follow horizontally back across the chart to the 950-ft. line. At this point note the current line intersected; in this case it is 500 amperes, which checks with the value computed. To find the approximate carrying capacity of the 1,000,000-circ.mil cable from the chart, reference is made to the circles on the next larger and smaller sizes, from which the


DIRECTIONS
To Find Wire Size corresponding to known current, voltage drop and length of circuit: From intersection of current and circuit-length lines follow horizontally across chart to voltage-drop line; at this point read wire size, using larger size if between two sizes.
To Find Voltage Drop corresponding to known current, wire size and length of circuit: From intersection of current and length lines follow horizontally across chart to wire-size line; at this point read voltage drop.
To Find Current corresponding to known voltage drop, wire size and length of circuit: From intersection of voltage-drop and wire-size lines follow horizontally back across chart to length line; at this point read current.
To Find Length of Circuit corresponding to known current, wire size and voltage drop: From intersection of voltage-drop and wire-size lines follow horizontally back across chart to current line; at this point read length.
To Find Carrying Capacity note position of circle near end of wire-size line. From this point follow horizontally back across chart to corresponding circle on current line. This current is approximately the allowable carrying capacity of the conductor if rubber insulated.
Current, Amperes
Double Length of Circuit, Feet
Size of Wire B&S. Gage
C.M.
Volts Drop
VOLTAGE-DROP CHART FOR DIRECT-CURRENT CIRCUITS

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allowable carrying capacity is seen to be between 600 and 700 amperes.

Similarly, to find how long a circuit can be run with a given current, wire size and voltage drop limited, the formula becomes:

$$L = \frac{E_d \times circ.mil}{21 \times I} \qquad (4)$$

Suppose a current of 200 amperes is to be passed through a 300,000-circ.mil line with an allowable drop of 20 volts. The cable is found to have ample carrying capacity, and the corresponding length is found to be $L = \frac{20 \times 300{,}000}{21 \times 200} = 1{,}430$ ft. From the chart this is found by locating the intersection of the 20-volt-drop line and the 300,000-circ.mil wire-size line, and following horizontally back across the chart to the 200-ampere line. At this point the length line intersected would be about 2,900 ft., this being the distance to the load and back. The single distance is therefore 1,450 ft. which checks closely with the computation.

For direct-current motors it is convenient to note that the full-load current ratings are approximately as follows: 8 amperes per horsepower for 115-volt machines; 4 amperes per horsepower for 230-volt machines; $1\frac{3}{4}$ amperes per horsepower for 550-volt machines. Also, it must be remembered that the code requires wire large enough to carry 110 per cent of the name-plate rating of the motor. Suppose a 50-hp. 230-volt motor is to be operated at the end of a 1,500-ft. line (total length 3,000 ft.), with 10 per cent voltage drop allowed at rated load. The full-load current is approximately 4×50, or 200 amperes, at which value the allowable drop is 10 per cent of 230, or 23 volts. Starting from the intersection of the 200-ampere line and the 3,000-ft. line and following horizontally across the chart to the 23-volt-drop line, the corresponding wire size is found to be between 250,000 and 300,000 circ.mils, the larger of these sizes being required to meet the voltage-drop requirement. The carrying capacity required in this case is 110 per cent of 200, or 220 amperes, and inasmuch as the 300,000-circ.mil rubber-covered conductor will carry 275 amperes, it will satisfy both the voltage-drop and current-carrying requirements, and is therefore the proper size for this case.

It should be mentioned that the foregoing formulas and chart apply only to direct-current lines. For alternating-current circuits the voltage drop is not so easily computed, depending on the reactance of the line as well as its resistance, and also on the power factor of the load. When the cost is not too great, it is good practice to install conductors that are larger than the current-carrying and voltage-drop requirements call for. Such a practice may save rewiring the circuit or running an extra line in case of future extensions.

The Viscosity of Steam-Turbine Oils

Factors Controlling Friction in Bearings—Viscosity at Operating Temperature the Most Important Consideration

By V. M. HATCH

THE bearings of steam turbines, of all of the prime movers, present the best example of an approach to perfect lubricating conditions, on account of the high speed at which the shaft runs. Ideal lubrication consists of floating the shaft on a film of oil so thick that the shaft never comes in contact with the metal of the bearing. This floating condition is brought about by the pressure built up by the oil film in the clearance space between the shaft and bearing and is influenced by many factors which are explained later.

When such a condition is created, the only frictional losses in the bearing are those due to the fluid friction of the oil film itself. This fluid friction is directly proportional to the absolute viscosity[1] of the oil. If the absolute viscosity is doubled, all other things being equal, the frictional loss in the bearing will be twice as much.

If the absolute viscosity of the lubricating oil were constant at all temperatures, the calculation of bearing losses would be much simplified, but such is not the case. The viscosity varies rapidly with a change in temperature, becoming greater as the oil is cooled and less as the temperature is raised. Consequently, the temperature of the film of oil between a shaft and its bearing has a great influence on the frictional losses developed.

The temperature of this film of oil is very difficult to measure because of its extreme thinness. A rough approximation can be made by inserting small thermocouples in the bearing surface at several points. The temperatures indicated by these thermocouples may be used as an indication of the temperature of the oil film at the given points. It will probably be found that there is a considerable difference in the temperature of the oil film at various points in both the circumference and length of the bearing. This will be due to the variation of the thickness of the oil film at different points of the circumference caused by the eccentricity of the shaft with respect to its bearing. Since the frictional resistance of an oil film is inversely proportional to its thickness, it follows that the resistance will be greatest where the bearing clearance is the least. The greater frictional resistance causes a higher local temperature.

Of course the rapid rotation of the shaft constantly changes the oil in the clearance space so that the heat is distributed and lowered by the introduction of fresh oil. The thermocouples will show the highest temperature at the point of least clearance, which will be in a direct line with the application of the load, and the lowest temperature at the point of introduction of

[1] The ordinary idea of viscosity corresponds so closely with the scientific definitions of it that it is not worth while going deeply into the matter here. Expressed roughly, if one flat surface of definite area is slid over another at constant speed with an oil film of definite thickness between them, the absolute viscosity is proportional to the drag on the moving surface. On account of the difficulties of operating the instruments designed to measure absolute viscosity directly, there have been developed a number of instruments that are simple to operate and that measure something depending on the absolute viscosity. These instruments and the corresponding measures of viscosity include the Saybolt Universal (commonly called "Saybolt" and extensively used in the United States) Saybolt Furol, Redwood Standard, Redwood Admiralty, Engler and Barbey.

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fresh oil, which should be at the point of least pressure. The amount of the load or the pressure per square inch due to the load, has no influence on the frictional losses in such a bearing, other than its effect in reducing the thickness of the oil film.

The location and design of oil grooves also has a marked effect on the temperature at various points on account of the quantity of fresh oil that may be supplied. The distortion of the bearing or shaft due to heat or load, the inequalities of the bearing or shaft surfaces, and the vibration of the rotor, all cause variations in the thickness of the oil film in the bearing. All such variations of thickness result in a variable resistance and temperature.

Bearing Temperatures Misleading

These many variables make it difficult to measure or even estimate the actual temperature of the oil film. The usual methods of measuring bearing temperatures, by inserting a thermometer in a hole in the bearing cap or by measuring the temperature of the oil leaving the bearing, are not only inaccurate but very misleading as to the actual temperature existing in the bearing clearances.

As previously stated, for a given film thickness the frictional loss of a shaft fully supported by an oil film is directly proportional to the absolute viscosity of the oil in the clearance, and as this is, in turn, dependent upon the oil temperature, it is a difficult matter to calculate in advance what the frictional loss will be. For a perfectly cylindrical, concentric shaft and bearing the frictional resistance can be calculated from the following formula:

$$\textit{Resistance in pounds} = \frac{VD^2LN}{41{,}900{,}000\ C}$$

where V equals absolute viscosity, centipoises; N equals r.p.m.; D equals diameter of shaft, inches; L equals length of journal, inches; C equals radial clearance, inches.

Such perfection of bearing conditions never exists, and as the shaft is always eccentric with respect to the bearing, the frictional loss calculated from the formula given must be multiplied by a constant determined by experiment.

Because the frictional loss within a bearing under any given set of conditions varies with the absolute viscosity of the oil, it follows that the oil with the lowest absolute viscosity that will maintain full floating support of the shaft will produce the least frictional resistance. If the viscosity is too low, it will fail to build up a sufficient pressure to hold the shaft off the bearing and prevent metallic rubbing with resultant wear and increased temperature.

The pressure built up in the clearance space between the shaft and the journal is dependent upon the speed of rotation, the clearance, the load, the design of the oil grooves and their location as well as upon the absolute viscosity of the oil. A highly viscous or a heavy-bodied oil will develop a higher film pressure than a light-bodied oil, but it has a higher frictional loss. On the other hand, the factor of safety against abnormal conditions is greater with the high-viscosity oil than with the low-viscosity oil, always provided that the oil is fluid enough to be carried into the clearance space in the proper quantity. It is quite possible, and sometimes actually happens, that an oil is used which is so viscous that it cannot flow into the clearance space as fast as it is forced out by the action of the shaft, so that an insufficient film is formed with resultant wear.

In all of these statements it is the absolute viscosity of the oil at its operating temperature that must be considered, not the viscosity at some standard temperature, because the viscosity changes so rapidly with the temperature. If we can lubricate a turbine bearing at a temperature of 175 deg. F. with an oil having a viscosity of 56 seconds Saybolt Universal at that temperature, why should the same oil be used to lubricate another turbine bearing having a normal operating temperature of 150 deg. F.? At the latter temperature this oil might have a viscosity of 73 seconds Saybolt and its frictional loss might be 50 per cent greater than the loss at 175 deg. F.

One of the reasons why steam-turbine operators are allowing their turbine bearings to run at higher temperatures than formerly is because they know that the frictional resistance and losses are less. One of the large turbine builders is now designing his turbines so that the bearings will normally operate at 175 deg. F. in contrast to the earlier practice of about 150 deg. F. If the bearing conditions are the same, there is no reason why an oil having a viscosity of 56 seconds at 150 deg. F. should not be as satisfactory in a bearing at that temperature as is the oil with a viscosity of 56 seconds at 175 deg. F. in the higher-temperature bearing.

Margin of Safety

Aside from the actual frictional losses the factor of safety must also be considered. If the temperature of the 150 deg. F. bearing using the oil of 56-second viscosity were raised through unusual conduction of heat, a temporary failure of the cooling-water supply, or any other of the many sources of hot bearings, the viscosity of the oil might be reduced below the safe limit and bearing wear would result. Consequently, it is always advisable to use an oil of a somewhat higher viscosity than the minimum that will actually lubricate the bearings. This again points out the advisability of knowing the actual viscosity of the oil at its working temperature.

Furthermore, oils made from different crudes may have exactly the same viscosities at 100 deg. F. (the temperature at which all turbine oils are now standardized) and yet have quite different viscosities at the bearing temperatures. For example, two oils of different crudes may have a viscosity of 150 seconds Saybolt at 100 deg F. At 150 deg. F. they might have viscosities of 60 and 66 seconds respectively. This is equivalent to a difference of 13 per cent in the frictional loss, certainly an amount large enough to be given attention. On a certain type of steam turbine, in a unit of 2,500 hp., the use of an oil of too high a viscosity increased the frictional loss by 40 hp., all of which could be saved by the use of the correct viscosity.

Again, the viscosity of the oil in a turbine circulating system increases with use, owing to the evaporation of the lighter fractions of the oil. It is, therefore, highly advisable to have viscosity determinations made at frequent intervals in order that the increased frictional losses due to increased viscosity may be kept as low as possible by the addition of fresh oil of a lower viscosity than that in the system, in this way maintaining the viscosity of the oil within satisfactory limits.

Power-Plant Accounts—XVI. General Scheme of the Accounts

BY WILFRED A. MILLER

IN ANY set of books kept for accounting purposes, the ledger is by far the most important one. If properly kept, it serves as a complete history of the transactions that have transpired during the time since its inception. Into it, in the final analysis, go all the details connected with the prosecution of the enterprise for which it is maintained. Consequently, were all the other books of record to be lost and the ledger remain, it would be possible to reconstruct the progress of events from it. It is for this reason that so much stress is laid upon the ledger and its conduct.

We have now come to that stage in our work where it will repay us to take a general survey of this record in order to refresh our memories as to what it contains and what the contents represent. If we go over the entire ledger we shall find that we now have a considerable number of accounts, making up the following list: Labor, Fuel, Water, Lubricants, Ash Removal, Repairs, Scale Removal, Miscellaneous Supplies, Indirect Expenses, Investment, Total Cost, Income, Profit and Loss, Surplus, Reserve for Depreciation and Obsolescence.

Of these the first eight constitute a group by themselves, being the direct expenses of operation. Moreover, the direct and indirect expenses combined constitute the total cost of operation. It is then possible to arrange the list in the following manner:

Labor			Investment
Fuel			Total Cost
Water			Income
Lubricants	Direct	Total	Profit and Loss
Ash Removal	Expenses	Cost	Surplus
Repairs		of	Reserve, Depreciation
Scale Removal		Operation	and Obsolescence
Miscellaneous Supplies			
Indirect Expenses			

From this we see that the Total Cost account really contains the result obtained by combining the direct and indirect expense accounts. If the balance of the Total Cost account expresses the amount of the total cost in this manner, it is of course necessary that the balances of the direct and indirect expense accounts be zero, otherwise the ledger would make it appear as if the cost were twice as great as it actually is, since we would have the costs once in the Total Cost accounts and again in the individual accounts constituting the direct and indirect expense records. As a matter of fact, it will be remembered that the balances of the individual accounts are automatically reduced to zero in the process of entering into the Total Cost account the information it contains, because this information is derived from the individual accounts and during its transfer from the individual accounts to the Total Cost account the former are "closed," this operation usually taking place at the end of every month. Hence, after closing, the only accounts that might contain balances are: Investment, Total Cost, Income, Profit and Loss, Surplus, Reserve for Depreciation and Obsolescence.

These, in turn, may further be combined just as the direct and indirect expense accounts were combined. Thus, the profit made in any month is obviously equal to the difference between the income for the month and the total cost for the same period, this profit resolving itself into a loss if it should happen, as it sometimes does, that the total cost of generating energy is greater than the income received from its sale. From this it follows that the Profit and Loss account is nothing more nor less than a combination of the Income and the Total Cost accounts. Here again we found that the manner of making entries in the Profit and Loss account was to derive the amounts from the Income and the Total Cost accounts, and in so doing to close them out, so that their balances became zero. Therefore, after this second stage of the closing operation the only accounts that could show balances would be Investment, Profit and Loss, Surplus, Reserve for Depreciation and Obsolescence. Under normal conditions the Profit and Loss account will always show a credit balance; that is, a profit balance. This profit is, in the nature of things, the property of the mill as a whole and is held in the Profit and Loss account only until such times as it is properly available to be either transferred to the general books of the concern as our contribution toward the profits earned by it, or for other purposes. In our scheme of accounting we have arranged to retain the available part of the profit for our own use in the purchase of new equipment or similar purposes and so relieve the concern from the necessity of making provision for the purchase of such equipment for us. The amount removed from the Profit and Loss account for this purpose is transferred to the Surplus Account, from which it may be spent upon occasion, as indicated in previous articles.

We may now get up a schematic representation of the ledger accounts such as the one illustrated in Fig. 1. Each account is represented by a box, either large or small, and the interconnections between these boxes indicate how the information "flows" from some of them to be combined in others. As shown, all the other accounts, with the exception of the Investment and Reserve for Depreciation and Obsolescence accounts,

This is the last of a series of sixteen articles on Power-Plant Accounts that was started in the September 13 issue of "Power." The main purpose of this series has been to enable operating engineers, without any previous knowledge of bookkeeping, to set up and operate a standard set of accounts designed to give the real cost of power and put the power plant on the same basis as any other production department. This installment gives a general view of the system that has been developed in previous articles, as well as additional information regarding the relation of the various accounts.

converge toward the Surplus account. Hence, in the ultimate analysis the only accounts that are not contributory to the Surplus account are the Investment and Reserve accounts. As is clearly indicated by Fig. 1, these accounts stand entirely apart from all the others, having absolutely no connection with them. We could, however, combine them with the surplus-account balance to give a figure that would express the net worth of the power plant. This would work out as follows: We know that the true worth of our equipment is equal to the difference between the balance of the investment account and that of the reserve account. The only other source in our ledger from which we can derive anything that possesses potential value is the surplus account. This represents the value we have laid aside for the purchase of new equipment and like purposes. Were we to spend it, our plant would have that much more value in it. Although not yet spent, the value belongs to the power plant just as would the value of apparatus purchased with it. Consequently, in arriving at a total valuation we must add this to our other equipment value. Hence, the total value is determined by adding the balance of the surplus account to the difference between the balances of the investment and reserve accounts. Of course this is on the assumption that the surplus account contains a credit balance. Were it to contain a debit balance, the balance would not express a surplus at all, but would be an indication that we have incurred a debt which we must pay back out of future profits before we can again begin to accumulate a surplus. In such a case it would be necessary to subtract the balance of the surplus account from the difference between the investment and reserve accounts in order to find the true worth.

There may exist one source of wealth in addition to these just dealt with, which is not represented in the ledger, and that is cash on hand. It will be remembered that, if we are called upon to handle the firm's cash in carrying out minor transactions, we keep track of it in a special journal called the cash journal, or (more commonly) the cashbook, and that we do not post the entries in this book to the ledger because the book itself is laid out like a ledger account and serves both as a journal and a ledger account. This being the case, it is important that we think of the cashbook when dealing with the ledger, because it really is a part of the ledger. That is, we may look upon the complete ledger as being made up of two books, the first of which contains the cash account and the second of which contains all the other accounts. If there is any balance at all in the cashbook, it must be one on the debit side, since a balance on the credit side would indicate that we had paid out more money than was in our possession, which is clearly impossible.

Now the question arises, what shall we do with this balance in connection with figuring the net worth of the plant? In the case of the surplus account we added the balance if it was on the credit side, but subtracted it if it was on the debit side. Judging by this, we should deduct the debit cash balance from the net worth as already found. Would we be correct in doing so? There can, of course, be no doubt that the answer is no. In fact it would be more logical to look upon the cash on hand as adding that much more value to the power plant, because after all, it is only in our possession for the purpose of being spent in the interests of the plant. However, that argument would not hold either. Until the money is actually spent it does not belong to us, but is something which we owe to the concern. When we do spend it, it may be either for the purpose of defraying some expense or of adding to the equipment. In the former case its value would enter into the cost of power production and thereby be lost so far as plant value is concerned, whereas in the latter it would add directly to that value, in which case it would be converted into property belonging to us. So we cannot tell beforehand whether the cash is actually going to increase our valuation or not. We are only holding it in trust from the firm, and until we spend it for them it belongs to them. Hence we need take no notice of such cash in so far as it had any bearing on our plant value. It may just be ignored in this respect, although of importance as a record of its own.

The argument may be advanced that, if cash is treated in this manner, what we call surplus should also be looked upon in the same way, as something not belonging to the power plant until it has been spent. However,

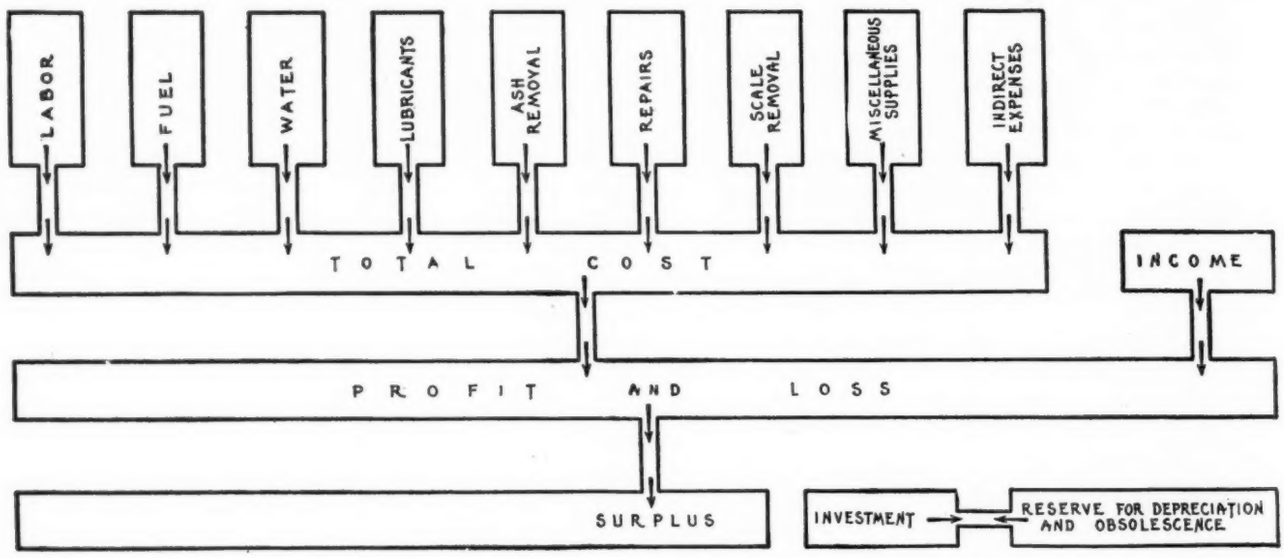


FIG. 1. DIAGRAM SHOWING THE RELATION OF ALL THE ACCOUNTS

there are two differences. In the first place, whatever value appears in the surplus account has been "earned" by the power plant, according to the scheme of accounting laid out. In the second place we know that this surplus is going to be spent for things that will increase the value of the plant, and not for any of the operating expenses, since the only object in establishing it was to accumulate a fund with which to make purchases of equipment of one kind or another.

While on the subject of the surplus and the purposes for which it is to be spent, we will do well to ask ourselves how we are going about spending it. So far as we are concerned it is merely a figure written in our books. We haven't it in money. Then how are we

	1921 June	30	Investment	Purchase of Equipment out of Surplus	200	—	
		30	Surplus	Purchase of Equipment	200	—	

FIG. 2. JOURNAL ENTRIES FOR EQUIPMENT BOUGHT WITH PART OF THE SURPLUS

going to spend it? This question brings out the fact that our accounts and those of the general books of the concern are all intertwined very closely. At least they must be if our books are to mean anything to the firm; that is, if they are going to be anything but the most elementary kind of records kept merely for our personal information. Thus, unless we have the co-operation of the management, it would be hopeless for us to attempt to concern ourselves with such things as taxes or interest, or even with such direct expenses as coal, water and the like. Therefore, it is a foregone conclusion that we must be in close accord with the bookkeeping department. For example, it would be meaningless for us to put into effect a system by virtue of which we allowed ourselves a profit and the right to retain that profit for our own use when available, unless we were first to go over the matter carefully with the management and receive their consent to the scheme. To establish it would mean that due record of the situation would have to be provided for in the general books of the concern.

When such provision has been made we will know that whatever amount we have in our surplus account, is duly recorded to our credit in the general books. Hence, when we wish to spend any part of it we have merely to notify the firm to that effect, and the goods will be purchased for us and paid for out of the general treasury exactly as are all other purchases made in behalf of the power plant. However, when the bills for such purchases come in, this distinction should be borne in mind, namely, that they are really purchased out of our surplus and that, therefore, our surplus account must be reduced by whatever amount we spend in this way.

The bookkeeper will likewise take cognizance of this fact and reduce the amount which he was carrying to our credit by that much. To take care of such transactions on our own books means that we must make two journal entries for purchases of this nature. First, we must make the usual debit entry to the investment account, and, secondly, another debit entry of like amount to the surplus account, as illustrated in Fig. 2. In this way we would increase the investment account while at the same time decreasing the surplus balance in order to pay for the new equipment that was purchased out of it.

It may appear that if there is a profit balance in the profit and loss account, it, too, should be added in as part of the plant value, the same as is the surplus balance. A moment's thought will, however, convince us that this is not so. If we go back over our reasons for creating the account, we will see that its purpose was to keep track of the profit made on power furnished to the various departments, but that it was decided that this profit should not be touched until the goods that had been manufactured by that particular power had been sold. It was for the purpose of separating the profit so released from that yet "in process" that the surplus account was created. It is, therefore, only this latter account which may be considered as adding to plant valuation.

As already pointed out, inspection of the ledger, as illustrated diagrammatically in Fig. 1, shows that it is divided into two distinct groups. One of these consists essentially of the direct and indirect expenses, and the income corresponding to them, resulting finally in what we have chosen to call surplus. The other consists of the co-related Investment and Reserve for Depreciation and Obsolescence accounts. This division has a distinct meaning. A little analysis will prove to us that the first group is concerned entirely with the operation of the plant as a business venture, whereas the second concerns itself solely with the value of the plant used in the business. The combined investment and reserve account stands aside as the capital with which we are carrying on our business; the other accounts are the ones we have to use to find out whether, in making use of that capital, we are compelling it to earn a profit for us, or whether we are allowing ourselves to suffer a loss thereby. The only relation that exists between the two groups is that the result of one is to be added to or subtracted from the value of the other, according to whether a profit or a loss has been made. That is, all the other accounts might be looked upon as working for the investment group, which keeps itself entirely apart from the general activity and is interested only in knowing at the end of a period whether money has been earned for it or not.

Spraying molten metal on all kinds of materials for ornamentation or for protection against corrosion is now being done extensively by the Schoop process, according to the *Compressed Air Magazine*, which describes the process at considerable length in the November issue. The most modern development of the device that makes it possible is the so-called electro-pistol, in which an arc is formed between the ends of two wires of whatever metal is being used as the coating. A jet of compressed air under about 45 lb. per sq.in. is applied directly at the arc and sprays the molten metal on the object. The wires are fed together just fast enough to hold the arc. Powdered metal can be used instead of the wires, and an oxy-acetylene flame is substituted for the electric arc, in another model of the device. The principal use of the process is in galvanizing, but there seems to be great possibilities for it in other fields, as the spraying may be done with many different metals and upon almost any material—even wood and porcelain.

What difference does it make whether the excess profits are collected by the coal producer or by the same person or type in the guise of a railroad?

Pulverized-Coal System for Small Plants

A System Consisting of a Self-Contained Crusher and Blower Allows Pulverized Coal To Be Used in Small Plants

THE demand for a system or device by means of which poor grades of coal that are available in large quantities might be satisfactorily burned in pulverized form has caused boiler manufacturers to make a careful investigation of the various types of equipment obtainable for this purpose. The actual burning of pulverized coal has been an accomplished fact for some time and in itself needed no great amount of further thought, but the condition contributory to and

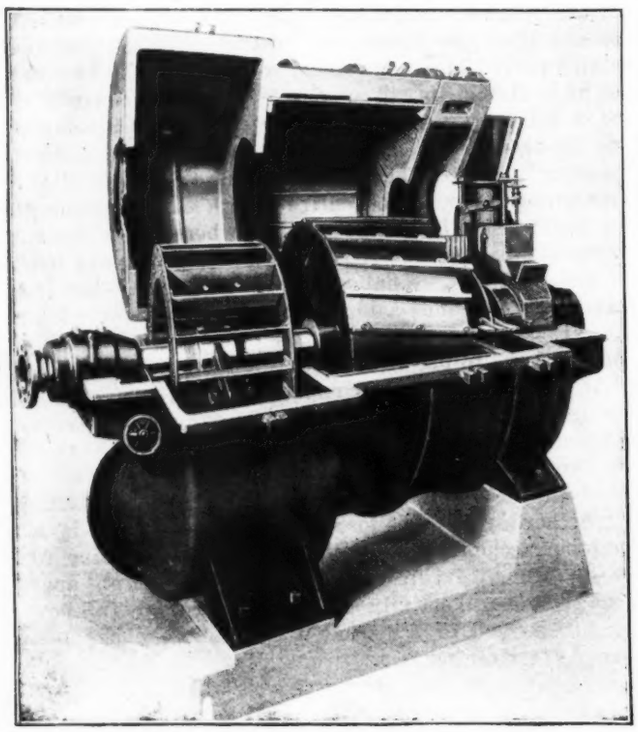


FIG. 1. SEYMOUR COAL PULVERIZER

resultant from its burning presented great difficulties. To begin with, the ordinary apparatus used for pulverizing and handling the coal while it is being prepared for the furnace, is so complex and costly to install and maintain that the average plant owner or boiler user would not consider the investment a wise one in plants of moderate size. The problem of deterioration of furnace refractories and the formation of hard slag, which could be avoided only at the sacrifice of furnace efficiency, seemed to trouble the operating attendant more than anything else. With these principal obstacles in mind to be overcome, the Erie City Iron Works equipped a horizontal water-tube boiler having 4,000 sq.ft. of heating surface at their Erie, Pa., works to burn pulverized coal.

Experiments conducted on this boiler resulted in the development of the Seymour Pulverizer, which is now being manufactured by the Erie City Iron Works. It consists essentially of a cylindrical stator or housing, with a rotor consisting of the pulverizing elements and a fan mounted on a shaft therein. Detail of design of the pulverizer is easily understood by reference to Fig. 1.

In operation, coal of a size that will pass through a 1½-in. diameter ring, is fed to the pulverizer through a simple adjustable feeding device. After the coal is reduced to a sufficient degree of fineness by the pulverizing elements and thoroughly mixed with air that enters through the suction orifice of a fan, this mixture of air and pulverized coal is blown into the furnace where combustion takes place. Both coal and air supply are subject to instant and easy regulation to suit any variations of load conditions.

The Seymour furnace, designed and patented by Frederick Seymour, was installed under the boiler. Its principle of water-cooling seems to insure long life of refractory furnace lining, and it also provides a hot pavement for the furnace, through a central longitudinal opening in which all molten slag and ash find

DATA AND RESULTS OF EVAPORATIVE TEST

Arranged in accordance with Short Form advised by Boiler Test Committee of American Society of Mechanical Engineers. Code of 1912

1.	Test of No. 11—Horizontal W. T. boiler located at East Power House, E.C.I. Wks., to determine efficiency. Conducted by W. C. Heckeroth	
2.	Kind of furnace—Pulverized coal	
3.	Grate surface, sq.ft.	None
4.	Water heating surface, sq.ft.	4,022
5.	Superheating surface, sq. ft	
6.	Date	4-14-21
7.	Duration, hours	8
8.	Kind and size of coal—Pittsburgh bituminous slack.	
	Average pressure, temperatures, etc.:	
9.	Steam pressure by gage, lb.	151.3
10.	Temperature of feed water entering boiler, deg.	50
11.	Temperature of escaping gases leaving boiler, deg.	479
12.	Force of draft between damper and boiler—at outlet, lb.	0.13
	In furnace lb.	0.038
13.	Percentage of moisture in steam	1.85
	Total quantities:	
14.	Weight of coal as fired*, lb.	12,050
15.	Percentage of moisture in coal	8.9
16.	Total weight of dry coal consumed, lb.	10,978
17.	Total ash, lb., from chemist's analysis	2,443
18.	Percentage of ash in dry coal from chemist's analysis	22.25
19.	Total weight of water fed to the boiler†, lb.	84,284
20.	Total water evaporated, corrected for moisture in steam, lb.	82,725
21.	Total equivalent evaporation from and at 212 deg., lb.	100,636
	Hourly quantities and rates:	
22.	Factor of evaporation	1.192
23.	Dry coal consumed per hour, lb.	1,370.7
24.	Water evaporated per hour corrected for quality of steam, lb.	10,341
26.	Equivalent evaporation per hour from and at 212 deg. lb.	12,542
27.	Equivalent evaporation per hr. from and at 212 deg. per sq.ft. of water heating surface, lb.	3.118
	Economy results:	
28.	Water fed per pound of coal fired (Item 19 ÷ Item 14), lb.	6.994
29.	Water evaporated per pound of dry coal (Item 20 ÷ Item 16), lb.	7.54
30.	Equivalent evaporation from and at 212 deg. per lb. of dry coal (Item 21 ÷ Item 16), lb.	9.148
31.	Equivalent evaporation from and at 212 deg. per lb. of combustible, lb. (Item 21 ÷ (Item 16 — Item 17)	11.75
	Efficiency:	
32.	Calorific value of one pound of dry coal, B.t.u.	10,938
33.	Calorific value of one pound of combustible, B.t.u.	14,068
34.	Efficiency of boiler and furnace $(100 \times \frac{\text{Item 31} \times 970.4}{\text{Item 33}})$, per cent	81.05

* The term "as fired" means actua condition, including moisture, corrected or estimated difference n weight of coal on the grate at beginning and end.

† Corrected for inequality of water level and steam pressure at beginning and end.

their way to the ashpit below. Fig. 2 shows the genera! arrangement of pulverizer and horizontal water-tube boiler with the Seymour furnace. The furnace is so constructed as to form a part of the circulatory system of the boiler. The water circulating through the tubes and headers which form the structure of the furnace, keeps the furnace temperature in the vicinity of the refractories below their melting point, thus preventing

their destruction. The heat absorbed by the tubes is used in the generation of steam by the boiler. By the use of this furnace it is practical to maintain higher furnace temperatures than in the ordinary type of furnace and to burn the coal with only 5 to 10 per cent excess air.

Furnace walls can also be arranged with an air space to provide a circulation of air over the firebrick lining, thus serving as a protection to the brickwork, and at the same time this air is preheated and then admitted through a series of openings into the furnace.

A number of evaporative tests have been conducted by the Erie City Iron Works engineers, assisted by engineers employed by other industrial organizations that were interested in the undertaking. The results of one test are given in the table. These tests prove conclusively that this extremely simple and compact equipment for preparing and burning coal in pulverized form constitutes real progress in the art of combustion.

This system, with a somewhat different furnace arrangement, can be used for burning pulverized coal under horizontal return-tubular boilers. This type of boiler, when hand-fired in the average plant, operates at approximately 50 per cent over-all efficiency. A great saving in coal is therefore possible when burning this in pulverized form. The results of a number of tests conducted on this type boiler at Erie show an efficiency of 74 to 75.2 per cent. No apparatus is required other than the pulverizer, a motor, or turbine for driving the pulverizer, and a plain pipe connection between the pulverizer and furnace. The power required to drive this apparatus is approximately 20 kw.-hr. per ton of coal. This will vary somewhat with the nature of the coal handled and its moisture content. Smokeless combustion is absolutely assured, as the proportion of coal to air is subject to easy and positive control at the pulverizer.

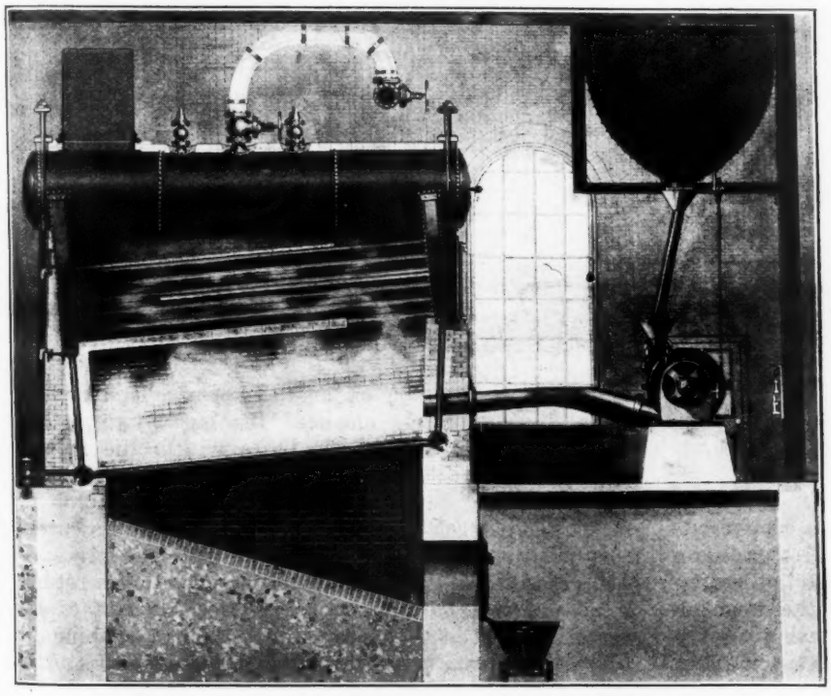


FIG. 2. SEYMOUR FURNACE FOR PULVERIZED COAL

Starting the fire in a cold setting can be accomplished by the use of kindling wood or an oil or gas flame. After the setting is once warmed up, the pulverized coal can be ignited by lighting a piece of oily waste. The cleanliness of operation, together with the absence of back-breaking muscular labor and other objectionable features of present-day boiler-room practice, makes this system worthy of the most thorough investigation.

Life of Cables on Traction Elevators

BY C. W. NAYLOR*

There has been much discussion regarding the life of cables on traction elevators. In the accompanying tables are given figures showing the wear of these ropes over a period of practically seven years, from July, 1914, until Nov. 1, 1921. The elevators in Tables I to III are eight Otis direct-traction machines, roped one-to-one, operating on a 250-ft. lift. The lower 100 ft. is express, or run without a stop, and the upper 150 ft. is local. The speed of the cars is 600 ft. per min., and they run 9½ hours a day 6 days a week, from 8:15 a.m. until 5:30 p.m., making about 17 miles per day per car. One of the cars in turn runs one-half hour earlier each morning and until 11 at night, making a total mileage for that particular car of 25 miles. The cars run in an inclosed hatchway in a warm office building, and the cables are not greased or oiled. The number of cable changes in an ordinary seven-year service would not be so great as during the last seven years. On several occasions inferior ropes were put on the cars because war conditions depreciated their quality. In Table I, *T* refers to traction ropes, of which there are six, ⅝ in. in diameter, 350 ft. long; *CC* refers to compensating cables, of which there are five, ⅝ in. in diameter, 300 ft. long; *CG* refers to the car-governor rope and *CWG* the counterweight-governor rope. The two latter, one of each to a car, are ½ in. in diameter and 600 ft. long.

By way of comparison a report, Table IV, is given on eleven traction machines having one-to-one roping, but the traction sheaves are driven by a worm and gear. The speed of these cars is 350 ft. per min., and they travel 15½ miles per car per day. All these cars run local. The first six carry passengers up only for nine-tenths of the time and the last five carry passengers down only for nine-tenths of the time; the remainder of the time they carry in both directions. The table covers traction cables only, of which there are six ⅝ in. diameter on each machine. There are no compensating cables on these elevators, this phase of operation being taken care of by chains.

From a comparison of Tables II and III it will be noticed that the compensating cables have in general a shorter life than the traction cables. This fact might be explained in that there is a twist in the former which is removed in the case of latter by vibrating

*Chief Engineer, Marshall Field and Co.

shackles. The drums over which the traction cables run are 36 in. and 33 in. in diameter. The sheaves over which the compensating cables bend are only 24 in. in diameter. There is a decided vibration in the compensating cables, or a swaying from side to side, which is not found in the traction cables. All these factors should tend to lessen the life of the compensating ropes.

TABLE 1. CABLE RENEWALS ON DIRECT-TRACTION ELEVATOR MACHINES

Car No.	1915	1916	1917	1918	1919	1920	1921
81	CG	CG CC	T	.....	.....	.....	CC
82	CG	CG CC	.....	CWG	CC T	T	CC CG
83	CG CWG	CC CC	.....	.....	.....	T CWG	.....
84	CG CWG	CC	.....	.....	CC	.....	.....
85	CG	CG CC	.....	.....	CC	.....	.....
86	CG	CG CC	CC	CWG	CC	CWG	CG
87	.....	CG CC	CC CG	.....	CC	.....	.....
88	.....	CG CC	CC CWG	CC	.....	T	.....

Cable changes: T, 5; CG, 15; CWG, 7; CC, 20; Total 47.

TABLE II. CAR MILEAGE OF (CC) COMPENSATING CABLES DIRECT-TRACTION ELEVATOR MACHINES

Car No.	1915	1916	1917	1918	1919	1920	1921
81	.....	11,500	.....	.....	.....	.....	27,500 1,450*
82	.....	11,500	.....	.....	13,900	.....	11,900 3,200*
83	.....	11,500 460	.....	.....	.....	.....	..... 27,600*
84	.....	11,500	.....	.....	17,500	.....	11,500*
85	.....	11,500	.....	.....	13,900	.....	15,100*
86	.....	11,500	2,750	.....	12,240	.....	13,900*
87	.....	12,800	2,750	.....	12,240	.....	13,900*
88	.....	12,800	1,300	10,100	.....	.....	16,300*

* Cables still in service Nov. 1, 1921.

TABLE III. CAR MILEAGE OF (T) TRACTION CABLES DIRECT-TRACTION ELEVATOR MACHINES

Car No.	1915	1916	1917	1918	1919	1920	1921
81	.....	.....	15,200	.....	.....	.....	24,800*
82	.....	.....	.....	.....	25,500	5,900	8,700*
83	.....	.....	.....	.....	.....	31,500	8,700*
84	.....	.....	.....	.....	.....	.....	41,000*
85	.....	.....	.....	.....	.....	.....	41,000*
86	.....	.....	.....	.....	.....	.....	41,000*
87	.....	.....	.....	.....	.....	.....	41,000*
88	.....	.....	.....	.....	.....	31,500	8,700*

* Cables still in service Nov. 1, 1921.

TABLE IV. TRACTION CABLE RENEWALS ON GEARED TRACTION ELEVATOR MACHINES

Car No.	Car Mileage Cables Renewed	Car Mileage Cables Renewed	Car Mileage Cables in Service
63	32,000	.....	4,500
64	30,000	.....	6,000
65	26,500	.....	9,400
66	.....	.....	36,000
67	35,600	.....	400
68	.....	.....	36,000
69	18,200	.....	17,800
70	18,200	.....	18,000
71	32,000	.....	4,500
72	16,200	10,200	9,800
73	26,500	.....	9,400

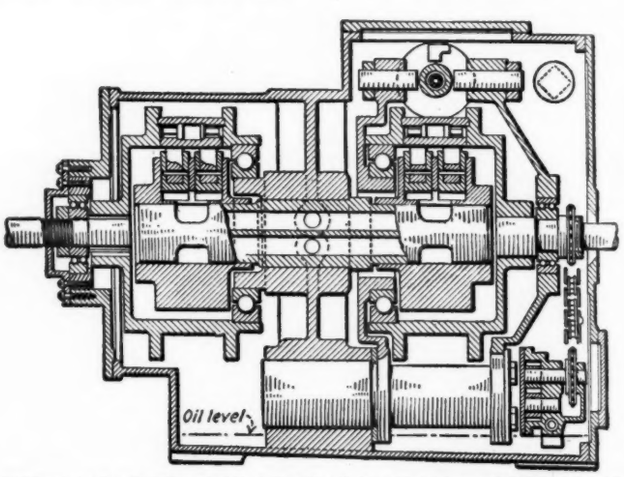
There seems to be a difference of opinion as to the exact cause for the increase in wear of the compensating cables. Most engineers and cable salesmen claim they have not noticed the difference. My operating elevator man says he attributes most of the wear on these cables to vibration. They always break from the inside, there being very little surface abrasion visible.

Variable-Speed Power Transmission and Feed-Control System

A speed-control system suitable for a wide variety of uses for which variable-speed power transmission is needed, is being put out by the Oilgear Co., Milwaukee, Wis. It consists essentially of a pump which can be adjusted through a wide range of delivery capacity, and a motor driven by the working fluid—oil received from the pump. The variable-speed drive receives power from a constant-speed lineshaft or constant-speed motor and delivers this power at any required speed from zero to a maximum in either direction, at an efficiency at full load of 85 per cent.

The cylinder barrel of either unit consists of a hub with central bore and five cylinders radiating from it. The bore of the hub is fitted closely around a ported pintle, and each of the radiating cylinders contains a plunger operated by a flat steel crosshead and delivering the plunger thrust through a roller bearing to a reaction plate on the surrounding driver. As the cylinder barrel revolves, each cylinder in turn registers with one of the ports as the plunger in that cylinder is moved outward, and after passing through a half revolution, the same cylinder begins to register with the other port and continues to do so while the plunger is moving inward. Therefore, each cylinder draws in a quantity of oil from the upper port and expels the same amount of oil into the lower port. The amount of oil handled by each cylinder at each revolution depends on the stroke. If the operator sets the stroke at zero, no oil will be pumped. If the pump is at maximum, a large, steady flow of oil is drawn in through one port and delivered through the other.

Each of these two ports communicates with a lengthwise passage through the interior of the pintle, terminating in a similar port at the opposite end of the pintle upon which is mounted the motor unit. The oil issuing from one of the ports within the motor-cylinder barrel pushes the plungers outward with whatever force may be necessary to compel the motor to rotate, and as each successive plunger reaches its outermost position, it ceases to register with the pressure port, crosses a bridge, and expels the oil into the return or low-pressure port during the succeeding half of its revolution. Thus the five motor cylinders combine to return the stream of oil through the low-pressure passage to be pumped over again back to the motor.



VERTICAL SECTION OF OILGEAR VARIABLE-SPEED DRIVE

The speeds selected by the operator are obtained irrespective of changes in load, unless the load becomes excessive, in which case an automatic overload gear relieves the operator of responsibility by preventing him from overloading the machine. The overload gear may be adjusted to any desired maximum load up to the capacity of the machine. When this is exceeded, th speed will be reduced, even to stopping the driven apparatus in case of a jam.

The system lends itself readily to various means of remote and pilot control; for instance, coal conveyors, coal pulverizers and stokers. It may be readily arranged so that pressure is the governing factor. On an automatic stoker drive, for instance, the speed may be varied automatically by the variations in boiler pressure relayed to a pilot valve.

Water in Steam-Engine Cylinders

Causes of Wet Steam and a Discussion of the Various Ways by Which Water May Enter the Cylinder of a Reciprocating Steam Engine

By I. L. KENTISH-RANKIN

BECAUSE cylinder-head fractures and other evidences of water in the cylinder have been singularly free from fatal consequences, there is a rather natural tendency to look upon these accidents as annoying and costly instead of classifying them as hazardous. That they are a hazard cannot be emphasized too strongly.

Water may enter a cylinder (1) when starting up the engine, (2) while the engine is running, (3) when shutting down, and (4) after shutting down. It may enter from the live steam line or from the exhaust line, depending upon conditions. Its entrance into the cylinder during starting and while shutting down finds little excuse as this can be prevented by precautions on the part of the engineer. Entry of water while the engine is running is the most difficult to prevent, because the effort must extend from the boiler-feed water line to the vacuum pump.

Cylinder Condensation

A large amount of water forms in the cylinder of an engine when starting up unless the temperature of the cylinder walls and piston has risen sufficiently to overcome excessive initial condensation. To warm the cylinder, the throttle should be "cracked" for sometime before starting. When this has been done and the cylinder warmed up and the condensation drained off by the drip cocks, there is little likelihood of water being entrained in the high-pressure cylinder on the one hand, or of water being drawn into the cylinder from the exhaust line due to the partial vacuum that is created in the low-pressure cylinder.

It is as necessary to warm up the receiver and low-pressure cylinder of compound engines as it is to warm up the high-pressure cylinder. This is generally accomplished by a bypass from the high-pressure steam line.

Notwithstanding general opinion to the contrary, engine drips are of little value for eliminating water in the cylinder once the engine piston is moving. These drips, which are usually located at each end of the cylinder and at the throttle, are valuable for removing condensed steam before starting up, but they cannot be relied upon to do more than this. Their orifices are so restricted and their inlets are so located that water cannot freely escape in the short time available as the piston moves through the cylinder; nor does the water readily find its way into the inlet offered because it is splashed onto the cylinder heads by the rapid movement of the piston, and lastly, the exit furnished by the relatively small drain restricts the flow of water. For safety, water must be kept out of the cylinder.

Shutting Down the Engine

Several conditions may arise preceding and while shutting down an engine by which water enters the cylinder. With compound engines either the high-pressure or the low-pressure cylinder may be the one affected, depending upon the reason for water existing. Water that enters the cylinder during the procedure of shutting down is due to carelessness.

When the boiler relief valve blows, the water level in the boiler rises owing to the more rapid formation of steam. If a high water level is being carried, water may be carried over into the steam line, and the engine may get a dose of it with serious consequences. The danger of water being carried over is increased by poor feed-water regulation or by a sudden dropping of load on the prime mover.

Another and entirely different set of conditions may exist by which water enters the cylinder from the low-pressure piping. Water may also enter the cylinder from the exhaust pipe while the engine is still running, because after the throttle has been closed a pressure below atmosphere exists and any accumulation of water in the exhaust line may flow into the engine. It may also occur when the pump of a jet condenser inadvertently stops, for water then rises toward the engine exhaust port.

A vacuum breaker is an important adjunct to all condensing equipment, but even with automatic vacuum breakers a potential danger exists in that they may fail to function properly owing to some derangement or because the incoming air enters at the wrong place or at too slow a rate.

Vacuum-Breaker Operation

Many of the so-called automatic vacuum breakers consist of a float that rises as the water rises until it finally operates the valve controlling the air supply. When this valve functions, air enters the condenser and stops the further influx of water upward toward the prime mover. If the float becomes water-logged, if the valve sticks or the mechanisms linking float and valve jam, water continues to rise and disaster may result if the defect is not discovered in time. The vacuum breaker should come in for frequent and careful inspection to assure that it is in proper working order.

It is important to locate the air inlet as close as possible to the engine exhaust port. Sometimes because of convenience the air inlet is located well down the exhaust pipe and water reaches the air inlet before air is admitted. This condition increases the danger of water entering the cylinder because the water and air mix, and since the specific volume of the mixture of water and air is lower than that of water alone, the water level rises more rapidly than would the column of water alone.

Another matter that calls for close attention is that the air-inlet valve has sufficient cross-section and positive action to permit the requisite quantity of air to enter the condenser to break the vacuum completely in a short lapse of time. These are some of the conditions that have been found to exist where an engine has been damaged for no apparent reason. They are avoidable.

In certain industrial plants the condenser is located on the engine-room floor, so that it is approximately at the same level as the engine cylinder. Usually, this arrangement exists where the condenser was installed as an afterthought and the absence of a basement necessitates placing the condenser on the first floor.

It is apparent that condensation may collect readily in the exhaust piping. It need not rise very high to reach the engine cylinder. If the condensate pump stops and the engine is shut down, the cylinder may draw water. The obvious remedy to combat this condition is to install the exhaust pipe vertically downward if possible so that any condensate that may be entrained will be harbored as far from the engine exhaust port as possible; and to insert a non-return valve close to the engine exhaust outlet.

An atmospheric relief valve should be installed in the exhaust line under all conditions, as it not only prevents the immediate shutting down of the engine should the vacuum be lost, but it protects the low-pressure cylinder against the piling up of high pressures. Fig. 1 indicates the location for the non-return and atmospheric relief valves.

Steam Separators

Steam separators are intended to remove small amounts of water from the steam. These may be efficient where there is low moisture content, but the efficiency decreases rapidly as the moisture content increases. The steam separator should, therefore, have ample separating surface for its work. The amount of steam passing through the separator per hour should determine the size of separator to use, and not the size of pipe feeding it. Higher steam velocities are more in vogue than formerly (especially where superheating is employed), so that smaller pipes are used, and if the separator size is based on pipe size, it may be too small for its job.

The efficiency of the separator depends on the condition of its surface. The collection of dirt, oily sludge,

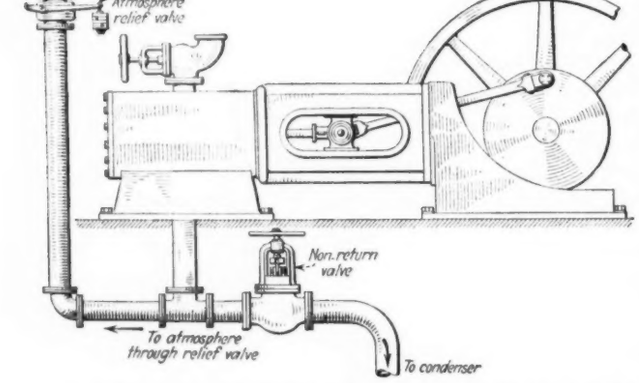


FIG. 1. DIAGRAM SHOWING LOCATION FOR NON-RETURN AND ATMOSPHERIC RELIEF VALVES

etc., lowers the effective separating surface. Where dirt is expected, generous separator surface is even more desirable.

A steam separator is effective only in so far as its drainage is effective. Doubtless many engine wrecks have been due to defective separator drainage. Another fact worth remembering is that a separator that becomes flooded creates a more hazardous condition than were no separator used at all, because a little water entering a cylinder may pass through without trouble, whereas a big slug of water, such as may easily occur where the separator is water-logged, will assuredly cause havoc.

Separator drainage pipes should be of ample capacity to assure ready drainage. The smaller the pipe the more likely it is to become clogged up. The capacity of a separator is determined by its drainage. The fewer fittings, the greater the simplicity of the piping and the more direct the path from separator to steam trap,

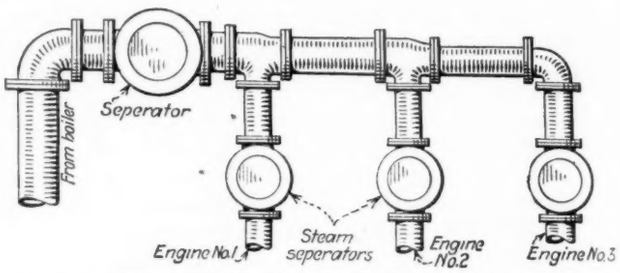


FIG. 2. TYPICAL STEAM-PIPING LAYOUT, SHOWING LOCATION OF SEPARATORS

the better. Where valves or cocks are intsalled, they should be locked "open."

A practice that has much to recommend it is that of inserting a receiver tank between the steam separator and the steam trap. If this receiver is two or three times the capacity of the trap, it affords opportunity to examine and overhaul the trap without interfering with the operation of the separator. It also lessens the seriousness of a clogged or inoperative trap. Many companies use a receiver for the separators in the main steam lines, when the moisture content is high, as well as for the individual engine separators. It is a worthy precaution.

Fig. 2 shows a steam-piping layout with a separator in the main header and one in each engine supply pipe. A slug of water has considerable inertia and will not turn to pass down a tee when it can pass straight along the pipe. This means that most of the water will reach the elbow and so pass to the separator of engine No. 3. This engine, therefore, is the one that may suffer most from water and the auxiliary apparatus, such as the steam separator, drains, steam trap, etc., require specially active attention. The greater length of pipe means greater condensation and so larger quantities of water for this engine.

Every engineer should watch and guard against the conditions enumerated below, as they cause the accidents which are blamed upon "something that happened."

Causes of Wet Steam.—Priming or foaming: Impure water, chemically or mechanically, through oil, kerosene, foreign matter in suspension, excessive water treatment, concentration; excessive evaporation rates; excessively high water level; faulty feed-water regulation; blowing relief valve.

Causes of Water Reaching Engine.—Faulty pipe drainage; insufficient steam-separator liberating surface due to dirty and clogged surfaces; insufficient drainage, drain pipes too small because clogged with dirt; absence of drainage, drain cocks turned off; defective steam trap.

Any of these conditions can arise in any plant. But if any one should arise, how long can it continue in your plant? That is the criterion.

EDITORIALS

Watching the Coal Man

ALL of us are inclined, in the absence of elaborate instruments, to ignore those tests which may be made with tools available to all. For example, it is not absolutely necessary, although desirable, to have a chemical or calorific test made of the coal purchased. The heat per pound of combustible in any typical coal is fairly uniform. The amount of combustible per pound of coal purchased is, on the other hand, by no means uniform. Since it is the combustible only that is burned, it is well worth while to find this percentage or to find the percentage of ash.

If the engineer will secure an ordinary crucible with a cover, he can crush up a pound of coal, place it in the crucible and then set the latter in the boiler furnace. After an hour or so the combustible will all be consumed and the remaining substance is the ash and dirt which is purchased along with the combustible, but which is absolutely of no use—in fact, is a detriment. The engineer is now in a position to speak with some degree of exactness when he approaches the management or the coal dealer. Once the latter learns his coal is being so tested, it will be surprising how quickly the percentage of ash and dirt decreases. The cost of coal is from sixty-five to eighty per cent of the total operating costs of the power plant, and a reduction of non-combustible from twenty to ten per cent of the coal would often equal the total labor cost in the plant.

Errors in Tests

IT IS by no means infrequent that when the results of some test on a prime mover have been challenged, upon investigation serious errors in the manner of conducting the test have been disclosed. At times the errors may be traced to a lack of complete understanding of all the factors having a bearing on the problem. More frequently, however, errors may be set down as due to negligence and carelessness on the part of the investigators. In other tests the lack of proper measuring instruments causes gross errors in the result.

Unless the test engineers have given serious thought to the problem and have incorporated in the scope of the investigation every single item that has any bearing on the subject, the test is doomed to failure from the start. If pressure gages, scales and thermometers are not carefully calibrated before the tests, the readings are, of course, worthless. The use of pressure gages to read low pressure values should never be countenanced, since no gage is accurate over the entire range of the dial. Mercury columns are much more reliable. Likewise, ordinary thermometers are of no use if any degree of accuracy of reading is required. Even the higher grades of thermometers may vary, and in places where the entrance and exit temperatures are taken, the interchanging of the two thermometers at stated intervals will rectify any existing error. Assistants should be instructed as to the proper method of reading. Seldom do two untrained men secure readings from the same instrument that do not vary by over one per cent. Carelessness in tests has had a detrimental effect upon engineering. Tests showing unusual efficiencies, even when conducted by experienced men, have been questioned by other engineers, and the public often places a heavy discount on such work. If an engineer has a desire to reach an honest result, has proper instruments and trained assistants, no reason exists why the results should not be reasonably accurate.

Hazards of Wet Steam

WATER is probably the major cause of engine wrecks in general and cylinder-head failures in particular. Considering the number of engines in daily use, the many different conditions under which they operate and the numerous contributing causes through which an abnormal amount of water may be carried over into the cylinder, one is forced to admit that engine wrecks are less frequent than might be expected. And, fortunately, comparatively few are fatal.

Nevertheless, the fact remains that water in any quantity is hazardous to both life and property. There is a tendency to overlook this fact by those brought into daily contact with the dangers of the power plant. Familiarity breeds contempt, it is said. But the engineer who feels contempt for water in his cylinders is courting disaster for his plant and jeopardizing his own safety.

The reasons why water may enter engine cylinders are well understood, for there is nothing mysterious about them. The actual reason, however, is often masked by other conditions. The methods by which they may be prevented are equally apparent. Plant layout, piping arrangements and pipe coverings may encourage or discourage the formation of water, but the use of proper equipment, proper maintenance of this equipment and the adoption of proper safeguards generally serve to prevent serious trouble.

Water may enter a cylinder while the engine is being started up or shut down or while running. The latter condition is the hardest to combat because water may result not from one cause alone but by a combination of several conditions, each partly beyond the control of the engine attendant, such as high water level in the boiler, or the sudden blowing of a relief valve may send a slug of water into the steam line. Priming and foaming due to bad water, oil or excessively high evaporation rates in boilers with insufficient liberating surface, are other so-called operating conditions that may endanger an engine. The conditions cannot be entirely obviated, perhaps, and so must be guarded against.

The steam separator is the last-line trench between the boiler and the engine. It is a piece of equipment that too often comes in for far less consideration and attention than its importance warrants. A fact often overlooked is that the steam separator is not a filter; it can only eliminate a certain amount of water from the steam, and how well it functions depends on how clean it is kept, whether it has sufficient liberating

capacity for its task and how rapidly the captured moisture is drained off. A separator is not intended to stop slugs of water, but entrained moisture. Drain pipes should be of ample size to keep the separator free, otherwise it may become a hazard of itself by the backing up of water.

In some quarters there is a tendency to omit the steam separator where superheat is used. Superheat lessens the likelihood of condensation and wet-steam troubles and so contributes to safety as well as economy. But the degree of superheat feasible with most reciprocating engines is not sufficient to justify the elimination of the separator. Even with turbines using high superheat the separator helps to reduce erosion of the turbine blading. Where conditions tend to produce wet steam, such as a long line, it is often well to insert a separator in the main line as well as immediately ahead of each engine throttle.

The important thing to remember is that water is liable to start off toward the engines in the best-regulated plants for any of several reasons and that proper plant layout, suitable equipment, adequate maintenance and eternal vigilance are the only antidotes.

Elsewhere in this issue is an article that brings out some aspects that might be overlooked as the day's work becomes a habit. It will serve to refresh the memory and awaken the conscience to the lurking dangers of wet steam.

Centralizing Control in the Power Plant

BEGINNING with the first plant for generating electric power, the tendency has been to concentrate the control of the generating units and circuits at some central point—at first on a switchboard near the generators themselves, and this practice, for small stations with hand-operated switches, has existed, to the present time. However, this location of the switchboard is determined more by placing it where the electrical functions can be conveniently looked after by the watch engineer than by any necessity for the man at the switchboard to see the equipment controlled from the board. In the larger stations, even at an early period in electrical power-plant development, the practice was to locate the control panels away from the generating units—at first on an open gallery overlooking the main units, then in a closed gallery, and now the control room is frequently in a building isolated from the main generating room. From this location the operator manipulates the control of the entire station without even hearing the sound of the machines or seeing a switch operate, being guided only by the reading of the instrument and signals in various forms.

On the steam end of the plant, with few exceptions, practically the reverse of what exists on the electrical functions is found. At each boiler there is a control and instrument board on which are mounted the devices for properly operating that unit. The control of the other auxiliaries is located at practically as many points as there are machines. In the more modern plants effort has been made to concentrate all the auxiliary equipment in the turbine room where it will be under the care of one crew of attendants. This is very desirable, but what is more desirable is concentration of the operation of the entire steam end of the plant at some central point where it will be under the direction of one highly skilled operator.

It is beginning to be generally appreciated that to obtain most efficient operation it is not only necessary to have the correct number of units on the system to carry the load, but also requires proper adjustment of the auxiliaries as well as the main units and boilers to this load. This is difficult to do and maintain the adjustment unless the control is under the supervision of at least one highly skilled attendant.

With centralized control it would be possible not only to have the boilers operate at their highest efficiency for a given load; but also to have worked out in advance the combination of equipment that would give the most efficient heat balance in the station for this load and have the plant operated on this schedule. Attempts are being made in a few cases to accomplish this end, but they are the exception rather than the rule. If it is advantageous to concentrate the operation of the electrical equipment under one skilled operator, how much more desirable to do so with the steam equipment, especially the boilers. As far as the over-all efficiency of the plant is concerned, it cannot be seriously affected by the manipulation of the electrical equipment. However, on the steam end it may be operating at high efficiency at one time and in a few minutes a change may take place that will seriously impair the efficiency. To be able to operate the present plants at their highest efficiency at all times, consistent with load conditions, is just as important as to improve the maximum efficiency over what it is at present.

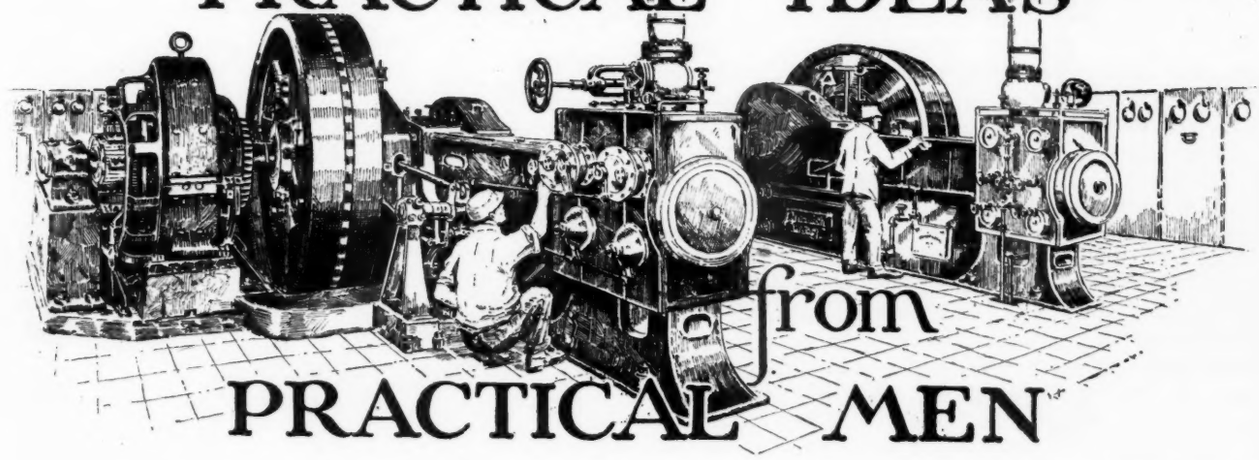
The reported discovery of a new natural-gas field in Northern Louisiana reminds one that perhaps our fuel resources are not quite so limited as they have been estimated. If the reports, credited as coming from the United States Bureau of Mines, are true, this field holds about five trillion cubic feet, the greatest natural-gas resource yet discovered. This is a tremendous volume of gas and, if properly utilized, will be of great value to the district within its reach. Are we going to profit by past experience in utilizing this new fuel supply, and abandon the wasteful methods of the past.

It is said of the president of a certain engineering society that, in his retiring address at the annual dinner, he chided the members severely for their very poor attendance during the year, as compared with their almost one hundred per cent attendance at the dinner. "You are stomach engineers," he said. "You seem to care nothing about food for the mind." There is more truth than tact in his words. It is well to remember that an undernourished mentality gives no better results than an undernourished physique, although its starvation is less noticeable, and so more dangerous.

The railroads lately agreed to reduce their rates by about one dollar a ton on export coal to seaboard points. Foreign consumers can choose other sources of supply when the price goes too high. Domestic consumers don't count—they have no choice. There is something wrong when Great Britain can sell coal in New England cheaper than our own producers.

The claim of the Bureau of Mines that a saving was made through the Government fuel yard is flatly contradicted by a firm of public accountants reporting to the National Retail Coal Merchants' Association. A good accountant could prove that we are in debt to Germany. The association's lobbying record hardly indicates innocent impartiality.

PRACTICAL IDEAS from PRACTICAL MEN



An Engineer That Should Have Been Fired

This tale is written so that if you are a competent engineer you can say, "Thanks be, if I die tonight I will leave no such mess for any man as Smith left for his successor."

The pulp and paper industry covers a big stretch of country and engineers by the name of Smith are numerous, so you can't locate the particular man or the plant, and they both exist.

As Smith ran a plant in the north country, I was surprised to get a phone call from him and more so to hear that he had landed a job in town, but was already wishing himself back in the wilderness again. "Come over and help us," was his plea, "or I must let someone else be engineer on this job."

He met me at the superintendent's office and took me to the steam plant. The fireroom was so full of smoke that it was impossible to see far, and I was some time making out that there were five boilers, two batteries of return-tubulars and one single water tube, all with underfeed stokers.

After walking around a bit, I began to get my bearings and take stock of the firemen. These fellows made no attempt to use the stokers on the first battery of return-tubular boilers, but simply loaded the furnace full through the firedoors, which did not fit any too well, being continually red-hot and all warped out of shape, and the blast from the fan blew a ring of flame and smoke all round them.

It was nearly impossible to breathe, and we could not see the smoke flue. We passed around to the back of the boilers and had a look at the stacks. The return-tubular boilers were all connected to a steel stack that had several holes in it large enough for a man to put his head into, besides many more as big as my fist and smaller.

To get rid of the smoke, windows were removed from their frames in the monitor, and while it was clearing away I watched the firemen and noticed that the stoker on the third boiler was also beginning to give trouble and occasionally the fireman gave it gentle assistance with a crowbar. A casual inspection showed that all the stokers were badly in need of repairs and would have to have a lay-off as soon as possible.

It was now late afternoon and gloomy enough in that hole. In the semi-darkness a red spot showed just under the tube door of the water-tube boiler, and on investigation it was discovered that the brick lining had fallen and the suspension beam was beginning to buckle toward the front. We stopped firing that boiler and sent for the mill manager. He was scared worse than we were, but kept his feet on the ground until we got the fire drawn and the boiler out of commission. It was not a pleasant job, and we did not save any expense in getting timbers to brace up that corner of the boiler.

In the morning we talked matters over and decided that as the steel beam would have to be replaced, it would be a good opportunity to overhaul the boiler and to raise it up at the same time. But it stood between the two batteries of return-tubular boilers and the smoke flue for one of them passed over the top of it, too close to allow it to be raised.

This water-tube boiler was purchased second-hand and had been installed by the mill people. To avoid the flue, they set the boiler so low that the stoker was in a hole, the bottom of which was about 30 in. below the floor level. It was desirable to get that stoker out of the hole and also to increase the height of the setting to get more combustion space, so the only thing to do was to move the smoke flue higher, and investigation showed that there was plenty of space under the roof to take it even higher than we wanted to raise the boiler.

While we were examining the flue, we discovered the squared end of a rod projecting from it, which proved to be the damper spindle from which the crank had long since been removed. A wrench applied to the spindle proved that the damper was about half closed. Then we found the crank and secured it in place so the damper would stay full open.

We had quite a hunt for that crank because all the timbers of the roof were loaded with an accumulation of soot and dust, and the crank and the greater part of the wire cable originally used to operate the damper were buried in dust. It had been arranged to work with a counterweight, and when the end of the cable nearest the floor was hooked to the last spike in the post, the damper was wide open. When the crank came off, it went up to the timber the pulley was on, and the fellow who pulled it there took a couple of turns of the damper cable around the post and let it stay at that.

Of course it was necessary to shut down the plant to get at the job, and a new steel stack was ordered at the same time. When the brickwork was removed we

could see into the boiler, and there never was a dirtier mess exposed to the light of day.

That boiler had been in operation continuously for almost a year. The back end was full of soot level with the top of the bridge wall, and it was caked between the tubes. The stoker was buried in dust and ashes. How they got steam is a puzzle, and we figured that it had not been cleaned since it had been put on the line.

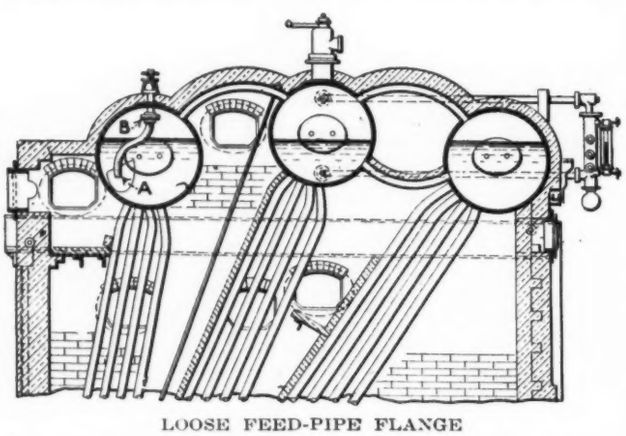
Though this firm has works at several places, it had no mechanical engineer and the rest of the plant showed the need of responsible supervision just as badly as did the boiler room. Steam pipes were uncovered and leaking, and other kindred sins of omission were in evidence everywhere. Smith and I wondered how the manager of any firm could be so blind as to allow such inefficiency, even if he had no mechanical training. We concluded also that an engineer who didn't get fired for fighting with the boss over such conditions was not so much either. Most men would have stuck to the boss until he could see how his money was going, or get fired.

Montreal, Canada. H. A. VINCENT.

Water Hammer in a Water-Tube Boiler

In our boiler plant, which contains two vertical water-tube boilers, we had a peculiar experience with water hammer, which I believe should be of interest to all who are handling boilers.

Our boiler, after operating for several years with little if any trouble, suddenly started to knock in the rear top drum. In fact, the knock became so violent as to cause the whole boiler to shake. After cooling the boiler, the manhole was opened and I went in to see if the baffle which acts as a mud drum was loose. This was tight and I could find no trace of anything likely to produce knocking. We fired up the boiler again, but the knocking was just as bad and all finally agreed it was some kind of water hammer. Cooling the boiler again, I re-entered the rear drum and upon close ex-



LOOSE FEED-PIPE FLANGE

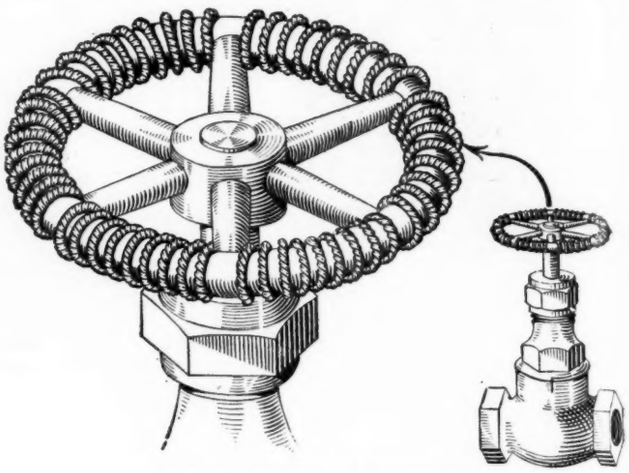
amination found that the bottom end of the feed pipe *A* was almost closed with scale and mud, and the flange coupling at *B* was somewhat loose. The pipe was cleaned and the flange tightened. From that time on no further hammer was heard.

I am of the opinion that the feed water spurting out through the flange coupling acted as a jet condenser, condensing part of the steam in the drum. This caused a partial vacuum, whereupon the water in the tubes, being under a higher pressure, rushed in the drum, giving out the sound of water hammer.

Brooklyn, N. Y. JOE L. GANS.

Preventing the Burning of Fingers

In working around the power plant one's fingers become very sensitive, due to oil, etc. In handling small valves on steam lines, the fingers, being sensitive,



CORD-COVERED VALVE WHEEL

often are blistered, and it is almost impossible to grasp the valve wheel hard enough to close the valve.

To eliminate this trouble in our plant, we have wrapped the handwheel of every steam valve, large and small, with manila cord, as shown in the sketch. This removes all the trouble and has the further advantage of giving a good grip in turning the wheel.

Chicago, Ill. F. L. GAUSS.

How to Measure Watts With a Watt-Hour Meter and Lamps

It is sometimes desirable to ascertain the power taken by small electrical devices when the only instrument available is the watt-hour meter in the power circuit. One way of doing this would be to connect the load to the watt-hour meter and count the disc revolutions for a given period and then calculate the watts by the test formula for the meter, but this requires a familiarity with the characteristics of the instrument.

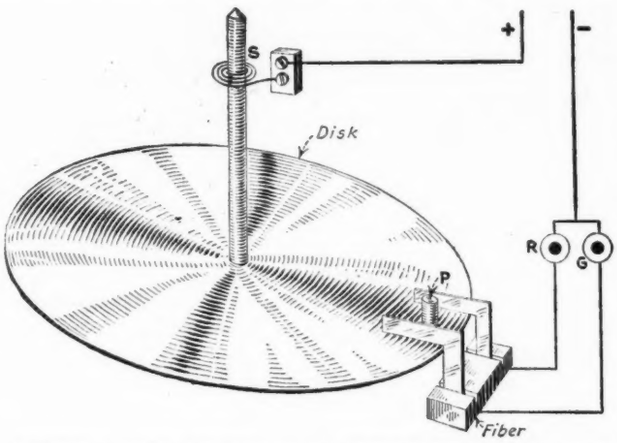
Another method that can be used, although not so accurate as the first, is to put a load of lamps on the meter and count the revolutions made by the meter's disc. It can be determined by the wattage rating of the lamps what the approximate load on the meter is. After this disconnect the lamp load and connect the device whose watts are to be determined. Count the revolutions of the meter for the same time as for the lamp load, then the watts can be determined by simple proportion. Say that ten 60-watt lamps were connected to the meter and in two minutes the meter disc made 60 revolutions, and when the device whose watts are to be measured was connected, the meter revolved 42 times in two minutes. The lamp load was $10 \times 60 = 600$ watts. The load to be determined is in direct proportion, therefore the unknown load in watts equals the lamp load times the revolutions for the unknown load divided by revolutions for lamp load, or in this case equals $(600 \times 42) \div 60 = 420$ watts.

This is only approximately correct since the wattage of the lamps will vary with the voltage and slightly with the age of the lamps. T. H. REARDON.

Northampton, Mass.

Contact-Making Voltmeter Made from A Watt-Hour Meter

Around almost any power house will be found an old watt-hour meter with the register missing or with some other defect which, while making it unfit for further service as a watt-hour meter, causes the engineer or electrician to hang it on a nail on the off-chance that he may some day use it. Engineers and other knights



GENERAL ARRANGEMENT OF METER DISK, CONTACTS AND LAMP CIRCUITS

of the continuous service order are built that way; they never throw anything away.

But the old watt-hour meter may, with a few minutes' rigging up, be made just as handy as anything in the plant, to indicate the rise or fall of voltage beyond certain limits, either supplementing or taking the place of an automatic regulator. Especially is this desirable in plants where the engineer is frequently called out of the engine room or away from the switchboard, and in small plants operated at times by one man, or where the load is subject to large variations compared with the capacity of the generators.

The contact making voltmeter suggested in the sketch can be set to indicate a variation of two volts above or below normal—quite a surprise to the writer, who didn't believe the meter was accurate to that extent, until after making an actual test.

An old Columbia type C-1 five-ampere 110-volt meter was used to make the device. A hairspring *S*, from an alarm clock was attached to the shaft and anchored under a convenient screw on the register bracket. A small brass pin *P* was riveted in a hole at the edge of the meter disc, and two brass springs, tipped with Ford spark-coil points, set in a stationary fiber block completed the job. Forty-five minutes was consumed; the meter was inventoried as junk, and a jeweler donated the hair spring. The register dial was the only part removed from the meter.

The wiring diagram shows the method of connecting up the red and green lamps, *R* and *G*, to indicate low and high voltage respectively. Although the writer's installation has only one set of these lamps at present in the boiler room, it is of course a simple matter to add as many sets as necessary, at points of vantage. The current coils of the meter are connected into the circuit in the regular manner through a 25-watt lamp which provides a source of load that gave the right amount of torque.

R. S. SEESE.

Chicago, Ill.

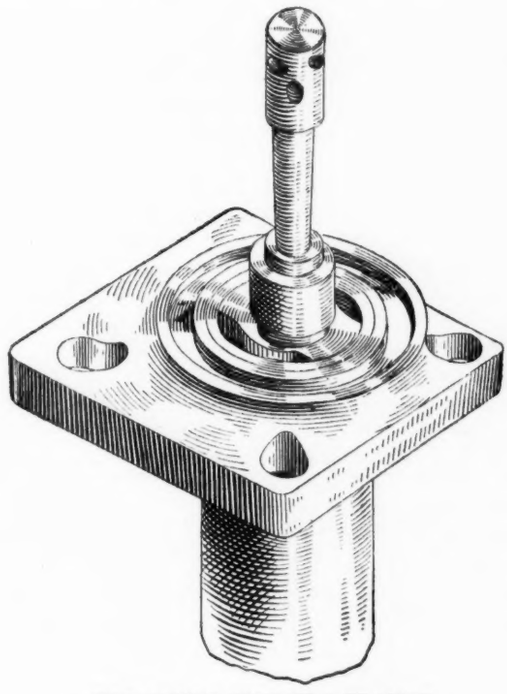
Stopping a Leaky Joint

Some of us, when things go wrong around the plant, are full of good ideas as to what to do. Others of us are so thick-headed that an idea must be pounded into our brains. Here is a true account of how a good idea was actually pounded into an engineer's head and was adopted with success.

The refrigerating plant had been overhauled and put in shape for the heavy summer load. But as soon as it was started up again, a leak developed in the discharge line between the compressor and the condenser. It was found that the gasket was tight, but that the ammonia was coming out along the threads between the pipe and flange.

The compressor was shut down and the flange unscrewed and the threads doped with glycerin and litharge. Upon starting, the leak showed up again, and we were at our wit's end. As I was passing through the door in order to get a little fresh air, something struck me on the head. I looked down at the object, which had landed on the floor, and discovered it to be one of several boiler-tube expanders the chief kept on a shelf and had rolled off.

The idea had finally pounded its way into my head. I immediately got one of the expanders, which fitted the leaky pipe, and after pumping out the ammonia



EXPANDING PIPE IN A FLANGE

proceeded to roll the pipe into the flange. The pipe was slightly burred, but the burr was removed with a file, which enabled the expander rollers to roll along the inner pipe surface.

The chief dropped in as we were working away and proceeded to declare that rolling a pipe would not stop the leak. Fortunately, he was the kind that was always willing for the men to try things out. After the job was finished, the flanges were drawn tight and the machine started up. No leaks showed up, and we have been operating ever since without the faintest sign of ammonia at the flange.

W. J. MURPHY.

New York City.

CORRESPONDENCE

The Mechanicsville Boiler Explosion

In the issue of Nov. 29, page 833, is published a description of a boiler explosion at Mechanicsville, and comment upon it is made in an editorial. Of course, in cases of this kind, where no one is left to tell what occurred, it is impossible to say if any untoward occurrence was noted just prior to the accident, and yet these mysterious explosions are of such importance that every effort should be directed toward their solution, and every line of investigation, even though it may result in nothing of importance, should be followed.

In the article the statement is made that tests on pieces of torn plate show a quality equal to present standards. It does not say what kind of tests were made, but presumably only the ones called for in the Boiler Code or similar ones. I very much doubt that these tests show the real quality of the plate. They will show certain things about it, of course, but my experience with steel used for welding purposes has convinced me that quality—that is, ability to give good results during the welding operation—does not depend at all on the ordinary tensile test and chemical analysis.

I believe that it is well known that the steel maker classifies his product for boilers, not altogether upon the results of physical or chemical tests, but on other qualities that cannot be determined by the ordinary methods; for instance, steel plate may be of "firebox" quality or of "flange" quality. It is well known that steel of "firebox" quality is necessary if good service in fireboxes is required. Such steel may be outside of the usual chemical limits of the Boiler Code and still be of "firebox" quality.

Moreover, the literature of steel shows many cases of so-called mysterious failures which contain hints as to some directions in which to look for further information than has been given. Some time ago, I think about three years, there was published in *Power* an article by a Canadian boiler inspector, complaining quite strongly of the lack of uniformity in the test results on boiler plate. This article showed clearly that there was something wrong with the steel which was not shown by the ordinary test, and particular cases to which he referred were not, in his experience, isolated ones.

In the case of the ruptured molasses tank at Boston some time ago, the fracture of the plates is described as "short and sharp." A notable article in this connection is the paper read by W. J. B. Wilson, which is to be found in the proceedings of the Engineers and Shipbuilders in Scotland for the year 1914, beginning on page 227.

In this article reference is made by one of the investigators, Dr. Arnold, to the notable angularity of the grains under microscopic examination. In this case, among other things it was found that the material was very weak to alternating stress, although it passed all Lloyd's tests satisfactorily, and these tests are more rigid than those of the Boiler Code.

It is well known that tests under alternating stress and shock will detect inferior qualities in steel which are not shown by the ordinary tensile test, and it seems to me that no investigation of such failures as the Mechanicsville boiler explosion is complete unless the material is submitted to these tests.

I have found in several cases that the strains due to welding of plate will produce cracks in steel of inferior quality in the metal near the weld, which has not been melted, but which has been heated to high temperature. In the vicinity of these cracks, the high-temperature grain boundaries are marked by visible films of oxide or other foreign matter. There is no difficulty in believing that these grain boundaries must have been originally weak owing to the presence of oxides in such small amounts as to be invisible under the microscope and yet comparatively thick.

The microscope will not show lines of a less thickness than of about 0.00001 in. which, compared with molecular dimensions, is enormous, as there are, roughly, about 30,000,000 molecules per inch, so that a film of comparatively great thickness of foreign matter could exist at the grain boundaries without being visible.

It is clear to me that a piece of steel of this character might contain microscopic cracks at the grain boundaries due to the breathing action of the shell which would be sufficient to account for the sudden rupture.

Rochester, N. Y. S. W. MILLER.

I have read with interest of the explosion of a horizontal return-tubular boiler in a paper mill at Mechanicsville, N. Y. Especially has my attention been attracted to the fact that no definite cause for the accident has been stated. Whether this may be attributable to the incompleteness of the investigation or to other reasons, of course I have no means of judging.

There is, however, one aspect of which I see no mention and which inspection of the cuts shown attracts my attention, that is, the possibility of the initial failure having occurred in the manhole reinforcing ring.

The account gives very little information concerning the construction of the exploded boiler, therefore an assumption that there may have been inherent weakness at the manhole opening possibly is altogether in error;

but for the reason that this point is, in some methods of construction, quite open to criticism, I feel an inclination to suggest it and to offer in support of such theory, the following.

An inspection of Fig. 1 in the article referred to, may be assumed to indicate that the initial failure was a comparatively gradual tearing of the plate at one or both sides of the manhole as an accompaniment of the failure of the manhole reinforcing ring, resulting in a fracture following the line of greatest stress and in a comparatively straight line, as might be expected if the plate was of good, uniform material.

With an opening thus made for the sudden release of the steam, the consequent rising of the water and sudden evaporation due to a considerable reduction of pressure may, conceivably, have caused a waterhammer explosion the violence of which caused the fractures, upon reaching the girth seams, to change their direction and also to divide and to tear out the V-shaped pieces illustrated, as well as to straighten out the end courses, causing the shearing of a large portion of the rivets in the girth seams, as noted.

It would seem to me that the illustrations rather point to there having been two distinct applications of force acting upon the structure—one gradual in its actions and the other of a sudden or explosive nature.

Whether the foregoing explanation is in line with the actual facts, or whether some other factors were dominant, it is a well-known fact that the manhole opening in the shell of a boiler is often the weakest point in the structure, and this is especially true when the reinforcing ring is on the outside of the shell, as was a popular practice some years ago with certain builders.

In this form of construction it was the usual practice to bolt on the cover in the same way as a blind flange, which introduced strains in the outer flange due to the bolts in addition to those due to the steam pressure. In this construction it would seem that considerable value was given to the stiffening effect of this cover plate, as I have figured some in which the strength of the ring alone was altogether insufficient to equal the strength of the rest of the shell or for the working pressure allowed.

CHARLES L. WARE.

Lawrence, Mass.

The article covering the boiler explosion at Mechanicsville, N. Y., on page 833 of the Nov. 29 issue, and especially the reference to the analysis covering the examination of the wrecked boiler after the explosion, has been read with interest. However, little practical information is set forth in this article, such as the age of the boiler, if insured and inspected by a boiler-insurance company, when the last external and internal inspection was made, if the boiler-feed was water treated and something as to the analysis of the water. Above all things, Was there a competent fireman, or boiler tender, on duty? Was he a regular man for the job or not? Also, in what condition were the tubes? Were they old or new, and were they well beaded over on the ends? What was the thickness of shell and the condition of the braces; were they all in their proper places and in good condition, or in a crystallized state?

After summing up the information published, I am inclined to dismiss the theory that an inherent defect in the safety valve resulted in a water hammer which caused the explosion. If the tubes were in bad shape and one or more of them let go at practically the same time, thus throwing additional strain on the surrounding tubes, the result would be that first one and then another might let go. The braces may have become crystallized and broke at the same time, which would allow the head to spring, resulting in further loosening of the tube and the final rupture of the boiler.

Victoria, Tex. H. W. ROSE.

Compensating Pressure Gages for Error Due to Elevation

On page 780 of the Nov. 15 issue E. W. asks for information on how to arrange his gages to compensate for the head of water in the pipe leading to them, and I submit the accompanying sketch as a solution of his problem.

He should not change the adjustment of his gages unless they are incorrect, and if so they should be checked and adjusted by a dead-weight tester or by an inspector's gage that is known to be correct.

The center of the gage shown by Fig. 1 should be level with the overflow tee. The overflow of condensation through the U-leg will prevent the head of water

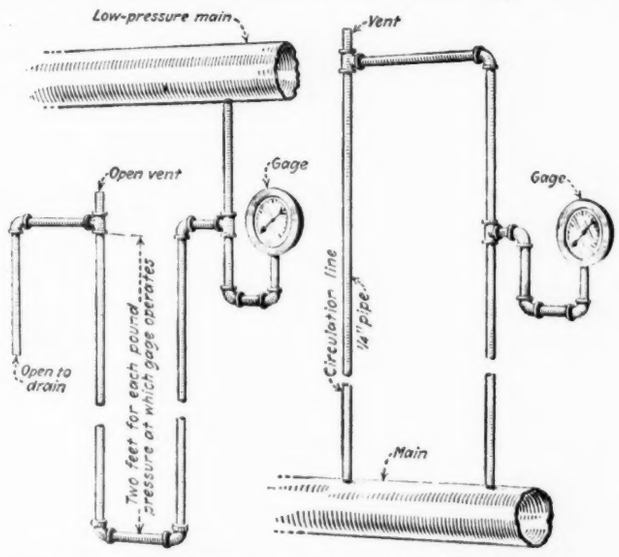


FIG. 1. PIPING OF GAGE

FIG. 2. ANOTHER WAY OF PIPING GAGE

accumulating in the pipe and showing a false pressure. Sometimes it is necessary to install a gage above the point of connection, probably with traps in the line so that the gage will then show a pressure lower than the actual pressure. In such cases I use the idea shown by Fig. 2.

W. T. MEINZER.

Brooklyn, N. Y.

Special Lap Tile for Boiler Baffles

Referring to an article on "Special Lap Tile for Boiler Baffles," page 690 of *Power* for Nov. 1, by L. E. Brown, our company and our agencies sell interlocking sectional baffle tile for which patents have been applied by the writer on tile of the character shown in the article referred to. To avoid possible infringement, in anticipation of patents which I may secure, by others who may have read this article, we ask that you publish in an early issue of *Power* the fact that the tile shown in Mr. Brown's article is covered by patents pending and controlled by our company.

SAMUEL F. BROOKS, General Manager,

Indianapolis, Ind. Power Plant Efficiency Co.

Causes and Remedies of Lateral Vibration in Turbine Wheels

Professor H. F. Moore is undoubtedly correct in his explanation that the rupture of the low-pressure disc in the turbine accident described in the Nov. 22 issue, was due to lateral harmonic vibration. It is not necessary, however, to search further than the singly flexed or lowest period vibration to locate the cause of rupture.

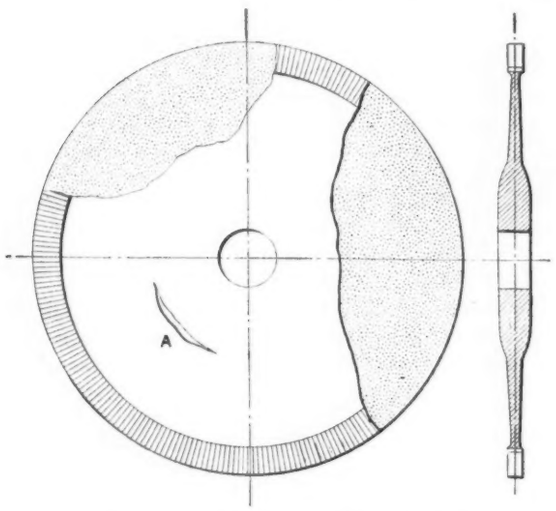


FIG. 1. SHOWS HOW WHEEL FAILED

At full speed such a turbine wheel is subjected to heavy stresses due to the centrifugal action of the mass of the wheel. This results in distributed tensions in all directions, including tangential and radial tension.

A laterally deflected wheel adds the stress of deflection to the already existing stress from rotation, and rupture occurs when the sum of the two tensions, repeatedly applied a sufficient number of times, exceeds the fatigue limit of the material employed. The wheel might have been amply strong to stand either the bending or the centrifugal stresses due to rotation alone, but was not able to stand indefinitely the sum of the two tensions.

Several years ago a machine designed by the writer was placed on test, and after preliminary runs it was noted that the high-pressure wheel had been rubbing laterally on the casing, where there was at least ¼-in. clearance between casing and wheel when stationary. The matter was immediately investigated, as it was not at once apparent what had caused the rub. After all other causes had been eliminated, it was found that the wheel had a natural period of vibration, with the buckets moving in an arc whose cord was parallel to the shaft, with a speed corresponding to that of the load speed of rotation. This condition was established by calculating the natural period of the wheel's vibration and was verified by physical experiment. At the time this occurred, it was a novel experience and realized to be a new factor in the design of steam turbines. The wheel in question was afterward run until broken, as shown in Fig. 1. Two sections of the wheel were torn loose, while at a third point a crack *A* extending clear through the disc was opened up for a short distance.

The character of the fracture on this wheel is identical with that of the large turbine wheel in the accident referred to in the foregoing. On a short, approximately circular arc, about midway between the wheel center and periphery, the fracture was fine-grained and of a character indicating a slow growth of an initial shallow crack. On the more radial portions of the fracture it was silky, with drawn-out fibers, giving indications of a rupture from tension. At the point *A*, Fig. 1, where the roughly circular arc crack passed through the wheel, there was found the same indications of a creeping fracture. It was evident that had it been possible to run the machine after the pieces had been torn loose, this fracture would have extended a sufficient peripheral distance to allow a third piece of the wheel to be torn loose by circumferential tension, as was the case for the other two pieces. If this third crack were added to the drawing of the ruptured wheel referred to in the first paragraph, it would become practically identical in appearance with the wheel, Fig. 1, and the description of the recently broken wheel would fit the wheel I had experience with.

In the writer's work on turbines he has used this factor of lateral vibration of the wheels as an essential feature of turbine design and has never had a repetition of the trouble. The precautions taken to prevent such an accident are comparatively simple, once the designers have available a method of calculation for determining the natural period of lateral vibration. An experimental method alone is awkward, since the wheel must be constructed before its critical speed can be determined. For this purpose a method is used similar to that employed by us to determine the critical speed

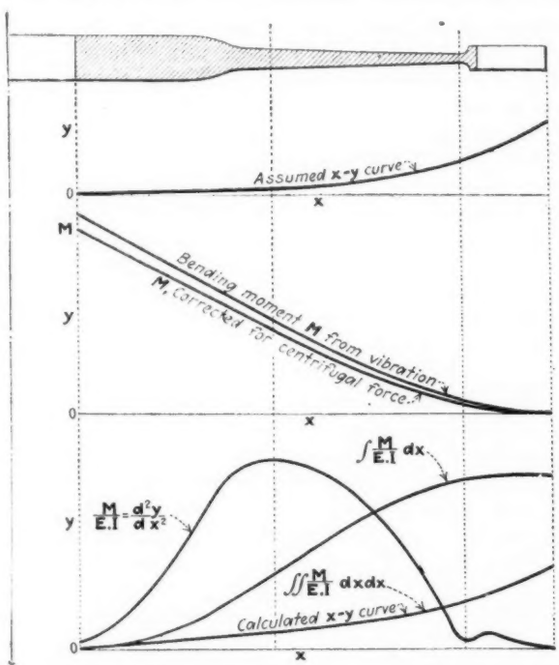


FIG. 2. METHOD FOR DETERMINING NATURAL PERIOD OF LATERAL VIBRATION OF TURBINE WHEELS

of shafts, which was worked out by the writer some twenty years ago. This method is briefly outlined in Fig. 2.

The general formula for any deflected beam is

$$\frac{d^2y}{dx^2} = \frac{M}{EI}$$

where x = length, y = deflection, M = bending moment, E = modulus of elasticity, and I = moment of inertia.

In the case in hand the right-hand number of this equation cannot be written in terms of x and y as an algebraic equation, but a curve may be drawn, which can be graphically integrated to give the xy curve represented by the equation. To do this, assume a probable curve of deflections; from this determine the corresponding curve of bending moments with the speed of vibration as an unknown quantity. From this curve of bending moments draw the curve of $\frac{M}{EI}$, E and I being known at all points from the wheel design. Since this curve is a curve of $\frac{d^2y}{dx^2}$, it is integrated twice with a planimeter to give a curve of x and y, containing as a factor N^2, where N is the critical speed sought. N is then found by setting the calculated xy line equal to the assumed line. If the calculated xy line is a materially different shape from the assumed line, the process should be repeated, using the first calculated line for the second assumed line.

In the writer's experience it has never developed that the second calculated line differed appreciably from the first calculated line, so that even if the first assumption be exceedingly faulty, a single repetition of the work results in an accurate solution for the critical speed.

The application of this method to the wheel, Fig. 1, resulted in a calculated natural period of wheel vibration which was some 3 per cent under the maximum speed of wheel rotation and corresponded almost exactly to the load speed of the machine. The tested natural period of the wheel standing still is slightly less than when in rotation, and the difference is also readily calculated with the foregoing method.

When running on its critical speed, a turbine wheel takes the shape in Fig. 3. Each element of the wheel is vibrating lengthwise of the shaft, but because the rotation of the shaft is at the speed of the vibration, the revolving wheel has a stationary deflection, the top being deflected to the right and the bottom to the left.

This condition requires that the action of the steam on the periphery of the wheel be such as to give slightly greater axial impulse at one point than at another point. If the steam action is absolutely uniform around the full periphery, this type of vibration cannot be set up. Such a condition of uniformity of steam action, however, is decidedly difficult to maintain and a very slight error in the spacing of stationary steam nozzles is sufficient to make vibrations possible. In the case of Fig. 1 the conditions were in the extreme, as there was but one comparatively short section of steam nozzle located at the bottom of the wheel, while some 70 per cent of its periphery was not provided with steam nozzles.

It is not a sufficient precaution to place the natural period of wheel vibration above the running speed unless at the same time the arrangement of steam nozzles is such as to make it impossible for the time between impulses on a given point of the wheel to correspond to the time of one complete vibration.

If a turbine be constructed with two short-arc steam nozzles, located on opposite ends of a diameter, and the critical speed of the wheel for lateral vibration be twice the speed of rotation, the same phenomena will be produced as for Fig. 1. The wheel periphery vibrates axially at double the speed of shaft rotation and receives two right and left vibration propagating forces per revolution. For this reason it is considered by the writer undesirable to use a turbine wheel whose speed of lateral vibration is close to the speed of rotation or close to twice the speed of rotation. Furthermore, the distribution of the steam nozzles around the periphery of the wheel must always be considered in connection with the speed of lateral vibration.

If a wheel be given a speed of lateral vibration less than the speed of rotation, it then passes through its critical speed when the machine is being started, and the resulting lateral vibrations, in time, could cause a rupture.

All these considerations taken together make the design condition such that as a general rule the speed of lateral wheel vibration should be in the neighborhood of one and one-half times its maximum running speed, or much higher. The danger points occur when the speed of vibration is a multiple of the speed of rotation, N, $2N$, $3N$, etc., where N is the speed of vibration—the higher the multiple the less the danger.

When the natural period of wheel vibration is the same as that of rotation, a very small lateral push from the steam at one point in excess of that at other points is accumulated to a large force whose energy is stored in the vibration of a given wheel element. As a result the produced deflection from a given force increases gradually with a lapse of time, until after several hundred rotations the swing of the wheel has a large amplitude and energy accumulated from several hundred impulses.

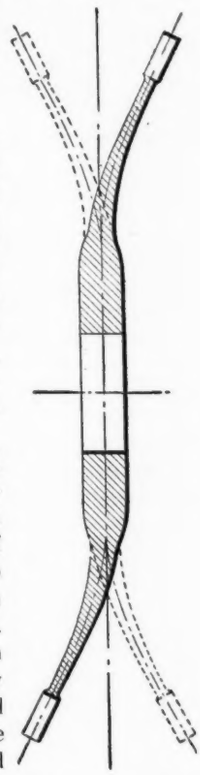


FIG. 3. SHAPE OF TURBINE WHEEL WHEN RUNNING AT CRITICAL SPEED

This question of lateral vibration has also an important bearing on the construction and mounting of turbine buckets, inasmuch as the mass of the wheel near its periphery is of more influence in lowering the natural period of vibration than weight located at any other position. It is preferable to use a mounting of buckets which gives a minimum weight at the periphery, and the heavier the turbine wheel the stiffer must be its section to maintain the same period of lateral vibration. Any turbine-bucket construction that calls for a heavy wheel periphery is for this reason doubly objectionable—first, because of centrifugal strains and, second, because of a lowered natural period.

The writer regrets that in this country it is the custom for engineering organizations to keep secret inside their precincts any special knowledge of engineering matters that refer to the design of machines on which they are engaged. This seems a short-sighted policy, for all suffer alike; the larger the company the greater is the waste of money that results from a lack of exchanged engineering information. Had it been customary to publish and openly discuss such matters of turbine design as this, large amounts of money would have been saved, and a recent very serious accident to a turbine of large power, which might readily have resulted in serious impairment of the operation of a large railroad, might not have occurred.

C. H. SMOOT, Engineer and Vice-Pres.,
New York City. Rateau Battu Smoot Co.

QUESTIONS AND ANSWERS

Omission of Beading from Tube Ends of Water-Tube Boilers

Why are not tube ends of water-tube boilers required to be beaded over at the ends as well as the ends of tubes in fire-tube boilers? H. A. C.

The tube ends of fire-tube boilers are beaded over so they will not become burned. In water-tube boilers heated gases do not come in contact with the tube ends and there would be no advantage from beading, as it does not certainly increase the hold of the tubes in the headers or tube sheets, and the process is likely to injure the texture of the tube material.

Ratio of Steam to Water Space in Return-Tubular Boiler

What relation does the volume of the steam space of horizontal return-tubular boilers usually bear to the water space? G. N. H.

The ratio varies according to the size, number and arrangement selected for the tubes. The volume of steam space included between the shell and a horizontal plane through the position of the central gage cock usually is between one-half and one-third of the net water volume below the central gage cock. Less steam space conduces to wet steam, and if the boiler is forced there is a tendency to foaming.

Double Stop Valves for Boilers

Why is it necessary to equip the main steam outlet of a boiler with more than one stop valve? C. S.

To provide against leakage of a single valve, there should be two main stop valves with a large bleeder and stop valve connected between the main valves for discharging any leakage to the atmosphere. This arrangement of double stop valves and intermediate bleeder outlet is imperative for the safety of a person entering a boiler when it is shut down for internal inspection while other boilers that are connected with the same header are under steam. Double stop valves are also highly desirable for installations having a single boiler in order to provide against annoyance from stop-valve leakage when making alterations or repairs to the steam line or connections while the boiler is under pressure.

Advantages of Reversing Rocker

What is the advantage of having a reversing rocker for the valve motion of a D slide-valve engine? W. L. B.

For a horizontal engine the reversing rocker is advantageous for transmitting motion of the eccentric to the valve when, for greater convenience, the steam chest is placed on top of the cylinder. It also is of benefit in obtaining quicker movement of the valve for admission of steam for the stroke of the piston from the head end of the cylinder. With direct connection the angularity of the eccentric rod causes the valve to move slower when admitting steam to the head end of the cylinder, and that adds to the difficulty of obtaining as high initial pressure in the head as in the crank end, due to quicker motion of the piston in the stroke from the head end from angularity of the connecting rod. By reversing the eccentric and using a reversing rocker for transmitting motion to the valve, the quicker valve movement is employed for better admission of steam for the quicker movement of the piston from the head end of the cylinder.

Higher Speed from Correction of Late Admission

After setting the valves of a 22-in. x 48-in. single-eccentric Corliss engine with sufficient lead to correct the late admission, the engine ran faster. To obtain the former speed, why was it necessary to remove some of the weight on the governor? J. S.

With prompter admission the mean effective pressure necessary for carrying the load was obtained with an earlier point of cutoff. But that could not be accomplished unless the speed was sufficient for the centrifugal force to hold the governor high enough for effecting the shorter cutoff. By removing part of the weights, less centrifugal force was necessary to hold the governor to the position that secured the necessary shorter cutoff, and by removing sufficient weight the higher position of the governor necessary for the reduced length of cutoff was obtained with the former slower speed of the engine.

Rebounding of Dashpot Rods

What causes the dashpot rod on a Corliss engine to rebound after it has dropped? S. N. A.

Immediately after being released by the cutoff mechanism, the dashpot rod is controlled by the movement of the vacuum dashpot pistons to which the rod is attached. In most forms of dashpots rebounding is due to air entering the chamber that acts as a vacuum pot during the upward stroke and tardy release of such air during the downward stroke.

When there is a separate cushioning chamber and the rebounding cannot be satisfactorily remedied by adjustment of the air-circulating valve in the dashpot proper, the trouble may be attributed to cushioning of the vacuum-chamber piston on air that has leaked into the vacuum chamber past the vacuum-chamber piston packing during the relatively slow upward stroke. When the valve arm and dashpot rod are released by

the cutoff mechanism, the downward stroke is quicker than the upward stroke, because the parts are urged by gravity and more or less unbalanced pressure of the atmosphere acting on the vacuum-chamber piston. Then by the time any air in the vacuum pot becomes compressed to the pressure of the atmosphere, the velocity of the piston is so great that the rate of discharge of the air through places of leakage or through a check valve provided for the purpose, may not be sufficient to prevent compression of the imprisoned air to a pressure considerably above that of the atmosphere by the time the piston has been brought to rest. The work thus stored in the compressed air causes the piston to rebound as though it had been dropped on a recoiling spring. There always is more or less leakage of the vacuum-pot packing, and if provision is made for automatic relief of excessive compression in the vacuum chamber, the rebounding can be limited to the very small amount due to regulation of cushioning.

Different Pressures Within a Boiler

An old engineer informs me that there are three different pressures in a boiler. Did he know what he was talking about? S. H.

He probably did, meaning at least three different pressures; namely, the pressure of the steam at the top of the boiler, the greater pressure at the water level due to the pressure and weight of the steam above the water level, and the pressure at the lowest point of the water, due to the depth of water, plus the pressure on the surface of the water. However, it also may be said that there is an infinite number of different pressures in the steam space as well as the water space, according to the level at which the pressure is taken into consideration.

Condenser Cooling-Water Fallacy

If a coil is placed in a tank and connected at one end to the suction header from the brine tank coils in a refrigerating plant and the other to the suction of the compressor, and the resultant refrigerating effect used to reduce the temperature of the condenser water, is it possible to cool the condensing water in this way without additional cooling by a cooling tower or spray pond? L. J. G.

All the heat removed in this cooling coil from the condenser water enters the ammonia vapor going to the compressor. This additional heat is still in the vapor when it enters the condenser and must be removed by the cooling water. If the water receives no cooling from a pond or tower, it cannot absorb any heat beyond the amount thrown off by it to the vapor in the cooling coils. Consequently, the vapor cannot be liquefied in the condenser. The system would not work. This may be followed in the heat charts of the article, "Solving Refrigerating Problems by the Total Heat Diagram," page 839, Nov. 29, 1921, issue.

Cost of Wasting Returns from Radiators

In the operation of radiators supplied with live steam at 12 lb. gage pressure, what would be the percentage of greater cost of generating the required amount of steam and discharging the condensate to waste by means of discharge traps, in place of returning the condensate to the boiler by gravity, if the temperature of the makeup feed water is 50 deg. F.? R. C. N.

Each pound of steam supplied to the radiators at 12 lb. gage pressure, or 27 lb. per sq.in. absolute, would contain 1,161.9 B.t.u. above 32 deg. F. Allowing that condensation takes place with reduction of 1 lb. pressure—that is, at the pressure of 11 lb. gage, or 26 lb. absolute—the temperature of the condensate would be 242.2 deg. F., and each pound of condensate discharged would contain 210.6 B.t.u. above 32 deg. F. When returning the water to the boiler by gravity, there would be a loss of heat from the return pipe, the amount depending on the conditions. However, if the heat radiated is utilized in warming premises that otherwise would require service of steam for the purpose from the same boiler, that would be equivalent to returning the feed water to the boiler with each pound containing 210.6 B.t.u., and for each pound (weight) of steam supplied to the radiators the boiler would need to deliver $1{,}161.9 - 210.6 = 951.3$ B.t.u.

But if the steam is generated from fresh makeup water at 50 deg. F., each pound of the feed for conversion into steam at 12 lb. gage would require, $1{,}161.9 - (50 - 32) = 1{,}143.9$ B.t.u., or $1{,}143.9 - 951.3 = 192.6$ B.t.u. more than when the condensate from the radiators is returned to the boiler with all the heat that it contained utilized for warming or returned to the boiler. Assuming that the cost of generating steam in each case is directly in proportion to the heat output of the boiler, the cost for supplying the radiators with steam and discharging the condensate to waste would be $192.6 \times 100 \div 951.3 = 20$ per cent more than when the condensate is returned by gravity to the boiler.

Kilowatt-Hour Consumption of Induction Motor

In our plant we have a three-phase 75-hp. 220-volt slip-ring induction motor. If the motor's full-load current is 185 amperes per terminal, how can I calculate the kilowatt-hour consumption of this motor when carrying full load? D. R. K.

In practice there is no way that you can calculate the kilowatt-hour load on the motor, since it would be very difficult to find conditions where the motor would operate constantly at full load. But assume a hypothetical case where the motor operates continuously at full load. Under such a condition the power factor will remain constant, provided the voltage and frequency remain constant, which in this problem is assumed to be the case. The full-load power factor will vary with different sizes, types and makes of motors, but for the sake of calculation assume 0.85, which is a fair average value. For a three-phase machine the kilowatts taken by the motor is $Kw. = \frac{E\,I\,\sqrt{3} \times P.F.}{1{,}000}$, where E equals the volts between the motor's terminals, *I* the current per terminal and *P.F.* the power factor. Therefore in this problem,

$$Kw. = \frac{220 \times 185 \times 1.732 \times 0.85}{1{,}000} = 59.92\ kilowatts.$$

Kilowatt-hours is equal to the kilowatts (constant load) multiplied by the time in hours. Consequently, in this problem, if the load was on the motor for 30 min. (0.5 hour) the kilowatt-hours would equal $59.92 \times 0.5 = 29.96$. In one hour the kilowatt-hours would equal $59.92 \times 1 = 59.92$, and in two hours $59.92 \times 2 = 119.84$.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Celebrating Stevens' Golden Wedding—1871-1921

The fiftieth anniversary of that pioneer school of Mechanical Engineering, the Stevens Institute of Technology, was celebrated by the alumni and invited guests at a banquet held on the evening of December 15 at the Hotel Astor, New York City. The attendance of over 500 Stevens' graduates and their friends included a large number of engineers and scientists of national and international fame.

Every class that has graduated was represented or heard from by letter or telegram, and a notable feature of the occasion was the attendance at the banquet of the class of 1877 with 100 per cent of the members present. Dr. Alexander C. Humphreys, president of Stevens and a graduate of the college, delivered an interesting address in which he reviewed the story of Stevens' growth and progress. Dr. John H. Finlay, former head of the New York State educational department, spoke of the good work of Stevens Tech, and the Hon. Job E. Hedges, a warm friend of Stevens, delivered an address that was full of wit and wisdom.

Between speeches and tactful announcements of the toastmaster, Harold E. Griswold, M.E., the grand old organ in the Astor ballroom piped merry and sentimental airs, including the old-time college songs of Stevens, and the men of other schooldays made merry, each class arising in turn to voice the college refrain of its day; and none of the songs and cheers were louder than those of the class of '77.

Plastic Fuel

Plastic fuel, or "amalgam" as it is called, is now added to our fuel sources as an intermediate form between liquid and solid fuels. This is the real significance of the first public announcement made by Walter E. Trent, of Washington, D. C., who spoke recently before the Washington section of the A. S. M. E. on his new process for de-ashing of coal and preparation of oil-coal amalgams.

Wet pulverized coal suspended in water, when treated with about 30 to 40 per cent as much oil as there is coal substance present, agglomerates into a pasty plastic mass in which all the carbonaceous coal substance and the oil join. The ash which has been mechanically separated from the coal particles by the fine grinding, does not go into the coal-oil mass, but remains suspended in the water and can be separated from the fuel paste almost perfectly. Thus there is produced a fuel material of about 15,000 to 16,000 B.t.u. per pound, which is practically free from water and relatively very low in ash content. The amount of moisture retained depends upon the proportions of coal and oil, being usually only a very small percentage. The amount of ash retained depends on the fineness of grinding and the character of the ash itself. All of that ash which is separated from coal by the fine grinding is eliminated, but that which is inherent in the coal or which is not mechanically separated from the carbon particles, remains with the fuel substance.

In a few cases the amount of ash can be reduced below one per cent of the treated fuel. Usually, however, two or three per cent of ash or in some cases up to six or eight per cent incombustible remains. However, this result can be obtained generally, and even very low grade fuels such as lignite, anthracite culm, and others from 30 to 40 per cent ash, lend themselves to this processing.

New Plant Designed To Handle a Thousand Tons of Raw Coal a Day When Complete

Mr. Trent, after two years of experimentation in small-scale plant process tests, has constructed, at the former Virginia Shipbuilding Corporation yards at Alexandria, Va., a plant designed to handle a thousand tons of raw coal a day when complete, but at the present time only one of the four units is complete throughout. At this plant Mr. Trent proposes to make his amalgam on large scale, not only operating regularly on various coals that lend themselves well to the treatment, but also treating experimentally special lots of 50 tons or more to determine the suitability of other fuels for use in the process.

A wide variety of oils can be used successfully. Gasoline, kerosene, benzol and the other high-priced oils are apparently no more satisfactory for the work than the very crudest of petroleum products. In many cases oil emulsions that are practically impossible to treat otherwise have been successfully applied. Thus Mr. Trent believes he will be able to take waste liquid fuels and waste solid fuels and by combining them, make a most satisfactory high-grade product.

It has even been suggested that the treatment of municipal ashes is entirely feasible, as in many cases the ashes collected (from domestic sources particularly) contain a high percentage of carbon, all of which can be recovered by this process. More promising, of course, are the possibilities of treating the inferior grades of coal and lignite which otherwise would not be applicable under present-day conditions.

The uses of the amalgam have not been entirely investigated, but it has been demonstrated that it is a material of great value for gas making either by treatment in coal-gas retorts or in water-gas machinery. Commercial-scale experiments on these types of gas making, as well as a limited number of tests on the manufacture of producer gas from the amalgam, give very encouraging results, Mr. Trent reports.

The amalgam can be burned upon a variety of stoking equipment, or it can be handled much as liquid fuels are and blown into the firebox through special burners with preliminary combustion in suspension and final combustion on the grate if this latter is desired. Mr. Trent is at the present time making the amalgam on a commercial scale and desires to extend the work gradually into these fields of amalgam utilization. He also anticipates extensive further work on the use of the amalgam for gas manufacture.

Government Puts Out Data on Artificial Gas

A recent report of the Geological Survey has the object of giving all the basic data for artificial gas and also for the byproducts of its manufacture.

Figures supplied by the gas companies of the country are summarized and analyzed to show average and extreme conditions of operation for various types and sizes of gas plants. Thus the industry can hope to find in many particulars standards of operating practice or operating efficiency by which to judge the general performance of the industry, and each operator will find a basis for comparison of his own results with those obtained by other operators of similar plants.

The report deals with artificial gas made by coal-gas, carbureted water-gas and oil-gas processes and with supplies of mixtures of these gases. It does not include any discussion of producer, blast-furnace, acetylene, Pintsch, or other industrial gases, which seldom form an important part of the municipal gas supply.

The summaries of data for gas and byproducts are given on several bases and thus permit consideration by product, by state or other subdivision of the country, by class of company, or otherwise, as may seem most significant and feasible. The effort has been made not only to serve the gas industry and those interested in public-utility gas supply, but also to furnish data for an intelligent study both of coal byproducts as furnished by gas companies and of the general fuel-engineering facts of greatest importance in that connection.

The trends of industrial development are briefly discussed at various points in this report, but the data for most satisfactory treatment of the industry as a whole will not be available for some months. A more complete discussion of the engineering development now in progress is reserved for the report of the calendar year 1920, in which it will be possible to consider changes in practice occurring just before, during, and just after the war.

The present report may be obtained free by request made to the Geological Survey at Washington for the advance chapter on Artificial Gas and Byproducts in 1917-18 of the "Mineral Resources of the United States, 1919, Part II."

News in the Field of Power

Hartford Section A. S. M. E. Holds Meeting

The Hartford Branch of the Connecticut Section of the American Society of Mechanical Engineers held an interesting meeting on Monday evening, Dec. 19. Following a dinner at the Bond Hotel, the members assembled in the auditorium of the Hartford Electric Light Co.'s building and listened to papers on "Manufactured Weather," by J. E. Bolling, of the Carrier Engineering Corporation, and "Refrigeration," by L. M. Church, of the Automatic Refrigerating Co. Both speakers evinced an intimate knowledge of their subjects and talked most interestingly, illustrating their discourse with numerous lantern slides. The subject of next month's meeting will be "Patents."

Electrical Review Bought by McGraw-Hill

The McGraw-Hill Company, Inc., publisher of *Power* and ten other technical and trade magazines, has recently bought the *Electrical Review* and is to continue to publish it in Chicago. The paper will be given a new name—*Electrical Review and Industrial Engineer*—and the effort will be to make it a practical monthly magazine devoted to the operation and maintenance of electrical and mechanical systems in mills and factories. It will thus be an extension of the work of the *Electrical World*, but it will deal with electrical problems from the practical, operating viewpoint instead of that of technical engineering. In explaining the purpose of the new addition to the McGraw-Hill group, James H. McGraw, president of the company, said:

With the extended use of electric service in industrial production processes, there has grown a demand for specific and practical information on the operation of electrical systems by those who take up the work where the consulting, designing and installation engineers leave off. For these practical men a service not heretofore available will be provided.

Edison Medal Goes to C.C.Chesney

The Edison medal, which is awarded annually by a committee of 24 members of the American Institute of Electrical Engineers "for meritorious service in electrical science or electrical engineering or electrical art," has been assigned for 1921 to Cummings C. Chesney, chief engineer and general manager of the Pittsfield works of the General Electric Co. The medal will be presented at the midwinter convention of the Institute at New York in February.

This medal is looked upon as the highest honor in America for electrical achievement, and has been awarded to such men as George Westinghouse, Alexander Bell and Nikola Tesla. Michael I. Pupin received the honor for 1920, the formal presentation of the medal being made at the Midwinter Convention of the American Institute of Electrical Engineers at New York City in February, 1921.

Mr. Chesney was born in 1863 in Selingsgrove, Penn., and was graduated from Pennsylvania State College with the degree of bachelor of science. In 1888 he associated with William Stanley, who, incidentally, received the Edison medal for 1913. A few years later Mr. Chesney became one of the incorporators of the Stanley Electric Manufacturing Co., and from 1904 to 1906 was vice president and chief engineer. He remained as chief engineer and manager of the Pittsfield plant of the General Electric Co. upon its amalgamation in 1906 with the Stanley Co., and still holds the same position.

South Meadow Station Formally Started

On Monday, Dec. 19, in the presence of some 300 guests the South Meadow Station of the Hartford Electric Light Co. was formally started.

After an inspection of the plant the guests assembled upon the main floor, where a rostrum and seating capacity had been provided, and progress views of the work from the breaking of the ground in March 1920 to the completed station were thrown upon the screen.

At 5 o'clock President T. G. Dunham gave a short sketch of the development of the company and Vice-President Samuel Ferguson told of the new project. On Dec. 19, 1904, just 18 years ago, the "Mammoth" Dutch Point Station was started with "4,000 kilowatts installed under one roof." Such an extravagant development excited apprehensive criticism on the part of timid stockholders, but that station has today nine times its old capacity, and the present demand is the largest in its history.

When the report of the Superpower Commission came out, Mr. Ferguson wrote to the Secretary of the Interior, "Your plans will not be delayed by Hartford, for Hartford is ready now."

Governor Everett J. Lake and Mayor Newton C. Brainard made brief remarks, and T. H. Soren, vice president of the Hartford Electric Light Co., and F. D. Knight, superintendent of construction of Stone & Webster, Inc., were introduced, as were also Richard W. Sheehan, who has been steam engineer and turbine engineer since 1889 with the company, Jeremiah Flynn, fireman since 1888, and Harry W. Palmer, switchboard operator since 1895. T. W. Wilbraham, the engineer-in-charge, has 31 years to his credit.

Governor Lake started the turbine, and Mayor Brainard closed the switch which threw the current onto the system. Two 20,000-cp. tungsten lamps (double the lighting capacity of any previously attempted), made especially for the occasion by the General Electric Co., attested the fact that the current was flowing.

The station was described in *Power* of Dec. 6, 1921, and is in keeping with the traditions of the progressive company which will operate it and the reputation of its builders.

Some of the notable features of the station are as follows: Earth handled, 52,000 cu.yd.; concrete for all purposes, 19,200 cu.yd.; reinforcing steel, 750 tons; structural steel, 2,600 tons; bricks in building walls, 2,500,000; floor area, 100,000 sq.ft.; Portland cement used in concrete, brick work, floor finish, etc., 180 carloads; lumber used for all purposes, 2,260,000 ft. board measure; material and equipment used in present development, 2,800 carloads; building now constructed for three generating units; one 20,000 kw. unit now installed; coal bunker inside building has capacity of 1,850 tons; piping for steam, water, air, etc., has a total length of 10.5 miles; conduit pipes for electric wires have a total length of 27 miles; capacity per square foot, 0.57 kw., the minimum of any steam station in the United States.

Lumber Trade Association Condemned by Supreme Court

The United States Supreme Court has decided the important hardwood lumber test case, upholding the Government's contention that the so-called "open competitive plan" of the lumber interests holds back production and boosts prices, and is unlawful under the Sherman anti-trust act. The decision is expected to have a far-reaching effect on other similar exchanges of trade information, such as that of the National Coal Association.

Justice Clarke, in delivering the Court's opinion, declared that the lumber association plan embraced the old trust "evil in a new dress," and that while there was no specific agreement as to production or price, the members were in a united action to get control of the industry. Answering the lumber argument that the Government itself issues information reports, the court pointed out that the Government reports are available to both sellers and buyers, while the association's reports were sent only to the sellers. The term "open competitive plan" was called misleading, as general competitors did not make reports. Justice Holmes, Brandeis and McKenna dissented from the decision.

Government To Study Unemployment at Bituminous Mines

Intermittent employment at bituminous coal mines is to be the subject of a comprehensive study under the direction of Edward E. Hunt, secretary of the President's conference on unemployment, in co-operation with the Department of Commerce. Secretary of Commerce Hoover has announced that private funds have been put at the disposal of the conference for carrying out the survey, which is to be the first of a series of similar investigations.

Proposed remedies will be studied, and attention will be given all phases of the problem, such as over development, seasonal demand, inefficient management and transportation difficulties.

Westinghouse Church Kerr Men Get Together

The "W.C.K. Alumni Association" was formed at a dinner in New York on Nov. 30 by 140 former employees of Westinghouse Church Kerr & Co., who met to renew the friendship made during their years of service with the company. The association was formed with the object of keeping that friendship alive, and the method of doing so agreed upon is to meet every Wednesday for lunch between 12 and 1 o'clock at Zimmermann's Restaurant, at 180 Fulton St., New York City. All who worked for the company for as many as three years are eligible to membership and are invited to get in touch with the secretary, A. H. Tummel, at 131 Warwick St., Brooklyn, N. Y.

The Spendthrift Coal Industry and the Thoughtless Consumer

"A Spendthrift Industry" is the title of a speech recently made by Dr. George Otis Smith, Director of the United States Geological Survey, in which he pointed out the waste-producing features of the coal-mining industry. In his indictment of the industry, however, he held the consumer partly responsible for the waste involved. He stated that nearly half of the irregular operation of the coal mine is due to a seasonal deficit in demand, which the consumer could largely prevent. In discussing this point he said:

The responsibility of the general public in its attitude toward coal has never been sufficiently emphasized. Indeed, the first step is to prove to the average citizen that he has any duty in the matter other than to pay for the coal he buys. But how does he buy coal? Those of us who from week to week watch the fluctuating demand have come to the conclusion that coal is largely purchased as it is used; a cold snap, a threatened strike by the brotherhoods, or a quick revival of business at once shows itself in the curve of daily shipments from the mines. The stabilization of the coal industry must begin with the consumer, who should buy from one dealer, who in turn should have his contract with the mine, the purpose of this settled arrangement being to insure a more regular flow of coal from the mine mouth to the coal bin.

Senator Frelinghuysen expects to address the Senate in the near future on his coal fact-finding bill. It is possible that he will try to bring the bill before the Senate for discussion, but it hardly is thought that he will attempt to press it to a final vote at this time.

New Publications

Thermal, Electrical and Magnetic Properties of Alloys. Bulletin No. 20. By Alpheus W. Smith. Published by the Engineering Experiment Station, Ohio State University, Columbus, Ohio. Paper, 6 x 9 inches; 86 pages.

A highly technical discussion reprinted from the Journal of the Franklin Institute for July and August, 1921. A large number of illustrations are included, some of which show the various properties of many different alloys in graphic form. Numerous references are made to other works on the same subject, many of which are in foreign languages.

Judging Coal Value. By Gerald B. Gould, vice president of the Fuel Engineering Company of New York. Published by the Fuel Engineering Company of New York, 116 East 18th St., New York City. Cloth, 6 x 9 inches; 32 pages.

The book is not presented as an addition to engineering knowledge, but as an effort to put accepted facts about coal into plain English that will be understandable to those not having technical training. It is intended to be of use principally to purchasing agents and others concerned with the buying of coal, and would doubtless be found useful by them, but hardly by anyone else, as it has practically nothing to say on the testing or burning of coal.

Obituary

John W. Duntley, who founded the Chicago Pneumatic Tool Co. in 1884 and served as its president until 1909, was killed by an automobile truck Dec. 15 in Chicago, his home city. Mr. Duntley was 55 years old and wealthy. He was director of the Taite-Howard Pneumatic Tool Co., of England, and was the head of the Duntley Automobile Accessories Co.

Robert H. McKean, manager of the credit department of the McGraw-Hill Company, Inc., died suddenly Dec. 17, 1921, at the age of 47. He joined the accounting department of the *Engineering and Mining Journal* in 1902 and was put in charge of the department before the paper was bought by Mr. Hill. About a year later he became manager of the *Journal*, and held that position until his election as a director and secretary of the Hill Publishing Co., when he took charge of the company's credit department. Upon the consolidation with the McGraw Publishing Co., he became manager of the combined credit departments and held this position until his death. Mr. McKean's loss is keenly felt, not only because of his unusual ability in his chosen work, but also for his ready wit and sense of humor.

Personals

Weller Rose has recently established a consulting electrical engineering office at Binghamton, N. Y.

H. O. Garman, national president of the American Association of Engineers, has established a private practice in consulting engineering and the management and operation of public utilities in Indianapolis, Ind. Mr. Garman valued more than $300,000,000 worth of Indiana utilities during his fourteen-year term as chief engineer of the Public Service Commission and the Railroad Commission of Indiana.

Society Affairs

Coming Conventions

American Society of Civil Engineers—Annual meeting at New York City, Jan. 18-20. Secy., Elbert M. Chandler, 29 West 39th St., New York City.

American Institute of Electrical Engineers—Midwinter convention at New York City, Feb. 15-17. Secy., F. L. Hutchinson, 29 West 39th St., New York City.

American Society of Mechanical Engineers — Spring meeting at Atlanta, Ga., May 8-11. Secy., Calvin W. Rice, 29 West 39th St., New York City.

Buffalo Section, A.S.M.E., will meet Jan. 4, 1922, for an address by A. M. Holcombe, of Washington, on "Patents and the Patent Law."

Virginia Section, A.S.M.E., will hold a meeting Jan. 6, 1922, at the Norfolk Chamber of Commerce, at which "Engineers as Industrial Managers" will be discussed by several speakers.

Worcester Section, A.S.M.E., is to meet Jan. 3, 1922, to hear a paper, "Mechanical Heating Problems Solved Electrically," by C. L. Ipsen, of the G. E. Co.

The Compressed Gas Manufacturers' Association, representing most of the manufacturers of compressed gases in this country, Canada, Mexico and Cuba, will hold its ninth annual meeting at the Engineering Societies Building, 29 West 39th St., New York City, Jan. 16, 1922, at 2 p.m. The annual dinner will be served at the Manhattan Club at 7 p.m.

The American Society of Steel Treating will meet Jan. 4 at Providence, R. I., for a talk on coal, oil and gas uel by George Darris, general manager, Gilbert & Barker Manufacturing Co.

The Iowa State Engineering Society will hold its twenty-fourth annual meeting in Sioux City, Iowa, Jan. 17-20. Manufacturers and material men will exhibit and prominent speakers are being secured. Headquarters and meetings will be in the Woodbury County Court House. A. G. Anderson, of Sioux City, has charge of the publicity work.

The Fifth Southern Textile Exposition is to be held in Textile Hall, Greenville, S. C., next autumn, probably in October. All who plan to exhibit at the affair are urged to communicate promptly with the Textile Hall Corporation, Greenville, S. C., as about one-third of the space has already been reserved, and applications will be filled in the order of receipt.

The Providence Engineering Society is arranging a joint meeting between its power section and the American Institute of Electrical Engineers for Jan. 3, at 8 p.m. "The Initial Hydro-electric Development for the Belgian Congo" will be discussed by William Frank Uhl, who is an associate of Charles T. Main, and has been over half a year in Africa making surveys for dam sites and storage reservoirs.

Business Items

The Ever-Tyte Piston Ring Division of the Walter A. Zelnicker Supply Co., St. Louis, Mo., is now represented in New York City by E. A. Bondemann.

The Warren Webster Co., of Camden, N. J., has appointed Edward W. Klein Southeastern district manager, to succeed John B. Dobson, who has had to give up active work because of ill health.

The Quigley Furnace Specialties Co., Inc., 26 Cortlandt St., New York City, is to be represented in the Chicago territory by H. M. Thompson, who was formerly with the Thomas Moulding Brick Co., with offices at 105 West Monroe St., Chicago, Ill.

The Randolph-Perkins Co., 1210 First National Bank Bldg., Chicago, which has been formed since the death of Edmund T. Perkins, is to carry on a general engineering business, specializing in land drainage, flood control, hydro-electric development, sewage disposal and water supply.

The Wayne Oil Tank and Pump Co., Fort Wayne, Ind., has bought the Borromite Company of America for $500,000. One of the important factors in the sale was the Borromite company's ownership of large beds of zeolite, a hydrous silicate used in water softening.

Trade Catalogs

Stokers—The Underfeed **Stoker Company of America, Book Bldg., Detroit, Mich. A well-illustrated booklet on a new type of Jones stoker, designed for side dumping.**

Piston Rings—Ever-Tyte Piston Ring Division, Walter A. Zelnicker Supply Co., St. Louis, Mo. "Saving Power in Coal Mines," an interesting booklet of testimonial letters from users of "Ever-Tyte" rings.

Condenser Tubes—Scoville Manufacturing Co., Waterbury, Conn. "Tube Facts," a short booklet illustrated with microphotographs of tubes of various materials and describing manufacturing and testing methods.

Centrifugal Pumps — Wheeler Condenser and Engineering Co., Carteret, N. J. Catalog 108-C, 64 pages, illustrating and describing Wheeler Centrifugal Pumps of the double-suction, single-stage, horizontal and vertical types and multi-rotor types for all purposes. Not only are the many different kinds of pumps for various applications described in considerable detail, but there is also included a good deal of material of instructive value, covering water velocities in pipes, characteristic curves, instructions for installation and operation, etc.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	Dec. 12, 1921	Dec. 19, 1921
Pool 1,	New York	$3.00	$2.75@3.25
Pocahontas,	Columbus	2.20	2.10@2.25
Clearfield,	Boston	1.80	1.60@2.00
Somerset,	Boston	1.85	1.65@2.00
Pittsburgh,	Pittsburgh	2.15	2.10@2.20
Kanawha,	Columbus	1.85	1.75@1.90
Hocking,	Columbus	1.95	1.85@2.00
Pittsburgh No. 8	Cleveland	2.05	1.95@2.05
Franklin, Ill.,	Chicago	2.75	2.75@3.00
Central, Ill.,	Chicago	2.50	2.25@2.75
Ind. 4th Vein,	Chicago	2.75	2.60@2.90
Standard,	St. Louis	1.95	1.90
West Ky.,	Louisville	1.75	1.50@2.00
Big Seam,	Birmingham	2.00	1.90@2.30
S. E. Ky.,	Louisville	1.75	1.65@1.80

New York—On Dec. 21 Port Arthur light oil 22@25 deg. Baumé, 5c. per gal. 30@35 deg., 6c. per gal., f.o.b. Bayonne, N. J.

Chicago—Dec. 21, for 24@28 deg. Baumé, 80@85c. per bbl.; 32@36 deg., 2¾@3c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh — On Dec. 13, f.o.b. refinery, Pennsylvania, 36@40 deg., 5@5¼c. Oklahoma, 24@30 deg., 95c. per bbl.; gas oil, 32@34 deg., 2¼@2¾c. per gal.; 34@36 deg., 3¼c., 38@40 deg., 3½c. per gal.

St. Louis — Dec. 10 prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 80c. per bbl.; 26@28 deg., 90c.; 28@30 deg., $1; 32@34 deg., 2½c. per gal.

Philadelphia — On Dec. 21, 26@28 deg. Baumé, Oklahoma, 80@85c. per bbl.; 30@34 deg.; Oklahoma (group 3), 2¼@2¾c. per gal.; 16@20 deg., Seaboard, $1.15@$1.25 per bbl.

Cincinnati — Dec. 21, for 26@30 deg. Baumé, 5¼c.; Diesel 32@34 deg., 6c. per gal.; distillate 38@42 deg., 7c. per gal.

Cleveland—Dec. 21, 26@30 deg. Baumé, 4¼c. per gal.

New Construction

PROPOSED WORK

Mass., Boston—The Bostonian, Inc., 75 State St., is having sketches made for a 10 story hotel on Arlington and St. James Sts. About $5,000,000. Desmond & Lord, 15 Beacon St., Archt.

N. Y., Buffalo—L. R. Steele Co., Inc., 323 Washington St., is having plans prepared for a 12 story, 60 x 107 ft. office bldg. on Washington St. About $400,000. Lewis & Hill, Brisbane Bldg., Archts.

N. Y., Long Island City — The Natl. Printing & Engraving Co., 136 West 52nd St., New York City, plans to build a 4 story plant on Washington Ave. from 6th to 7th Sts. About $400,000. Architect not selected.

N. Y., New York—The New York Edison Co., 30 East 15th St., is having plans prepared for a 50 x 100 ft. substation on Park Ave. and 168th St. About $150,000. W. Whitehill, 12 Elm St., Archt. and Engr.

N. Y., New York—E. J. Van Ingen, c/o Cross & Cross, 681 5th Ave., will soon receive bids for a 13 story, 40 x 100 ft. apartment hotel on 77th St. and 5th Ave. About $400,000. Noted Nov. 29.

N. Y., Syracuse—The Syracuse Memorial Hospital, Mrs. F. S. Wicks, Pres. Bd. of Trustees, plans to build a hospital. About $500,000. Architect not selected.

N. J., Camden—Hotel Co., Inc., c/o L. W. MacCleske, 503 Market St., will receive bids about Jan. 1 for a 15 story, 100 x 180 ft. hotel and stores bldg. on 7th and Federal Sts. About $1,000,000. K. Ellington, 230 5th Ave., Pittsburgh, Pa., Archt. A vapor or steam heating system will be installed.

N. J., Pleasantville—The Penn Motors Corp., c/o H. W. Sofield, 1719 North Broad St., Phila., Pa., will receive bids until Jan. 2, for a 1 story, 50 x 300 ft. factory and power plant. About $125,000. C. Donehower, Pleasantville, Engr.

Pa., Bellefonte—The Hecla Park Assn., W. C. Rowe, Mgr., Allegheny St., plans to construct an electric light and power plant to light park. About $50,000.

Pa., Harrisburg—The Bd. Educ., C. E. L. Keen, Pres., will receive bids until Jan. 6 for a 2 story, 80 x 200 ft. school on 3rd and Division Sts. Will take bids later on boiler room, etc. About $300,000. C. H. Lloyd, Suite 701A, Telegraph Bldg., Archt.

Pa., Phila.—J. T. Windrum, Archt., Commonwealth Bldg., is receiving bids for a 5 story, 88 x 201 ft. hospital on Powelton and Saunders Aves. for the Presbyterian Hospital. About $300,000.

Pa., Wilkesbarre—A. G. Kuehn Motion Picture Co., Inc., has had plans prepared for a 2 story motion picture studio. About $750,000. H. G. Cook, Jr., 716 Miners Bank Bldg., Archt. and Engr.

Md., Baltimore—The Continental Garage & Service Corp. J. C. Tolson, Mgr., 111 North Charles St., is having plans prepared for a 5 story, garage and service station on Monument and Howard Sts. L. Wagner, Union Trust Bldg., Archt.

D. C., Washington—The Bureau of Yards and Docks, Navy Dept., is receiving bids for power plant equipment, including the installation of four 150 hp. return tubular boilers and mechanical stokers, boiler and fire pumps, motor driven air compressor or installation and furnishing brick setting and super heaters for the four boilers, two turbine driven forced draft fans-steel smoke flue, feed water heater, heating system return tank, condensed equipment, air condensed and circulating pumps, service water heater traveling screen, structural supports, concrete foundations and pipes, valves and fittings. Spec. 4497. Noted Nov. 29.

D. C., Washington—The Episcopal Cathedral is having plans prepared for a cathedral and 30 buildings at St. Albans. Total cost, $15,000,000. Forhman, Ronn & Little, 24 Mt. Vernon St., Boston, Mass., Archts. Crain and Ferguson, 15 Beacon St., Boston, Mass., Engrs.

D. C., Washington—War Dept., Quartermaster, plans to build a 3 story Army Medical School building at the Walter Reed Hospital. About $500,000.

Va., Richmond—Hackley Morrison Co., 16½ North 9th St., is in the market for a 50 K.W. A.C., 3 phase, 60 cycle, 2300 volt alternator; 20 brick dryer cars, double or single; 200 or 250 KW. DC. 250 volt belted generator; 25 to 30 KW. 3 phase, 60 cycle, 220 volt, A.C. generator; one 40 hp. motor, 3 phase, 60 cycle; and motor driven centrifugal pump, 350 gal. per min. against 50 lbs. pressure.

W. Va., Wheeling—C. L. Hills, 403 North Bank Bldg., is in the market for refrigerating machine, 30 to 50 ton capacity, prefer horizontal designed for belt drive (used) also ice tank up to 50 tons capacity.

O., Akron—The city is having plans prepared for waterworks improvements to include an addition to purification plant, pumping station, buildings and watermains. Total cost about $500,000. G. G. Dixon, 102 East Mill St., Engr.

O., Cincinnati—Clifton-Pratt Co., 1224 West 8th St., A. E. Clifton, Purch. Agt., is in the market for one triplex, belt driven, 3 plunger hydraulic pump, 5,000 lbs. pressure, also 4 24 x 48 in. tumblers for foundry, belt driven.

O., Cincinnati—The Jung Brewing Co., 2014 Freeman Ave., A. Tiebermann, Purch. Agt., will abandon brewery and install additional ice making machinery.

O., Cincinnati—I. Oscherwitz & Sons Co., 569 West 6th St., M. B. Oscherwitz, Purch. Agt., is in the market for a 25 ton refrigerating plant and a 25 hp. horizontal boiler (100 lbs. pressure).

Ind., Hammond — The city is having plans prepared for a 65 x 95 ft. pumping station and a 50 x 75 ft. boiler plant. About $75,000. J. Erickson, 30 North La Salle St., Chicago, Ill., Engr.

Ind., New Castle—The Indiana Village of Epileptics will receive bids until Jan. 17 for 12 buildings, including a 64 x 100 ft. laundry and a 60 x 74 ft. power plant. Total cost about $400,000. H. Foltz, 843 Lenick Annex, Indianapolis, Archt. McManus & Tripp, 510 Majestic Bldg., Indianapolis, Engr. Noted May 17.

Ill., Chicago—P. F. Alsen, Archt., 127 North Dearborn St., is preparing plans for a 3 story, 122 x 250 ft. apartment, including a steam heating system on Newgart and North Shore Aves. About $500,000. Owner's name withheld.

Ill., Chicago—The city is having plans prepared for a 14 story, 100 x 150 ft. central courts building including a steam heating system on Harrison St. and Plymouth Court. About $2,500,000. C. W. Kallal, City Hall, Engr.

Ill., Chicago—F. A. Vaughn, Inc., 211 Grand Ave., Milwaukee, Wis., is receiving bids for a 500 kw. prime mover. D.C. and a surface condenser for the Amer. Hide & Leather Co., 1320 Elston St.

Wis., Fall Creek — The village having plans prepared for sewer and water works systems, including pumping plant, 80 ft. tower, 80,000 gal. tank. water mains, sewage disposal plant, etc. About $50,000. Toltz, King & Day, 1410 Pioneer Bldg., St. Paul, Minn., Engrs.

Ill., Henry—Henry Artificial Ice Co. is having plans prepared for a 1 story artificial ice plant. About $30,000. C. N. Lucas, Pres. B. L. Hulsebus, 1232 Jefferson Bldg., Peoria, Engr.

Ill., Rockford—G. C. Brown & W. C. Gridley, 1826 Hoffman Blvd., are having plans prepared for a 60 x 145 ft. garage, 35 x 60 ft. repair shop and a 20 x 30 ft. boiler plant. About $75,000. C. E. Wolfley, 610 Stewart Bldg., Archt.

Ill., Springfield — The Apartment Hotel Securities Co., c/o W. S. Newton, Pres., 5th and Capital Sts., is having plans prepared for a hotel apartment on 4th and Canedy Sts. About $900,000. Private plans.

Wis., Madison—(change of date)—The University of Wisconsin, M. E. McCaffery, Secy., will receive bids until Jan. 24 for a 6 story, 150 x 250 ft. hospital, including a steam heating system on Warren St. About $1,200,000. A. Peabody, Capitol Bldg., Archt. Noted Dec. 13.

Wis., Milwaukee—The Wisconsin Ice & Coal Co., 216 West Water St., is having preliminary plans prepared for a 2 story ice manufacturing plant. About $145,000. R. Messmer & Bro., 221 Grand Ave., Archts. 120 ton refrigerating machinery will be installed.

Wis., Stevens Point—The city plans election to vote Feb. 8 on developing new source of water supply including sinking of wells, pumping station, piping, etc. About $65,000. W. G. Kirchoffer, Vroman Blk., Madison, Engr.

Wis., Taylor—The city, c/o S. T. Nepernd, Clk., will soon be in the market for equipment and machinery for power plant and pumping station.

Ia., Bedford—J. J. Clark, J. H. Baker, and others, plan to build a power plant and ice and cold storage plant. About $200,000. Architect not selected.

Ia., Clinton—The Clinton Water Co., W. L. Meeker, Supt., 5th and 1st Sts., is having plans prepared for a 1,000,000 gal. reservoir, elevated steel tank, about 4 mi. additional mains, 2 mi. 24 in. pipe, new pumps, auxiliary pumping station at Lyons. About $1,000,000. L. S. Abbott, Weston Bldg., City Engr.

Ia., Muscatine—The city, R. S. McNutt, Mayor, plans to build a municipal electric light plant. About $250,000. Engineer not selected.

S. D., Watertown—The Public Utilities Comn., A. J. Mueler, Supt. Municipal Light Plant, will receive bids until Jan. 12 for a complete lighting system. Cost to exceed $40,000.

Tex., Halletsville—S. M. Kuykendall, City Secy., will receive bids until Jan. 12 for improvements to electric light plant, to include one steam engine, 120 to 150 hp. direct connected to one alternating current generator 90 kva. (or slightly larger), 2300 volt, 3 phase, 60 cycle, with exciter in proportion.

One switchboard panel for same.

One horizontal tubular boiler (return) 150 hp. for 150 lbs. steam, A.S.M.E. specifications with steel casing, stack and all fittings.

One 150 hp. open type feed water heater.

Two Simplex boiler feed pumps for this boiler.

Necessary interconnecting pipe fittings, steam separator receiver, etc. to operate in connection with present plant about 150 ft. away.

Cal., Redwood City—The trustees of the Sequoia Union High School Dist. are having plans prepared for a 1 and 2 story high school on State Hwy. and Bway. About $300,000. C. Werner and A. I. Coffey, Humboldt Bank Bldg., San Francisco, Archts.

Cal., San Jose—The Commercial Club, W. J. Cross, Secy., 1st Natl. Bank Bldg., is having preliminary plans prepared for a 10 story, office building on South 1st St. between Santa Clara and San Fernando Sts. About $400,000. Binder & Curtis, 255½ 1st St., Archt.

Cal., San Jose — The County of Santa Clara, is having plans prepared for a 3 story service bldg. including an engine room, cold storage plant, etc. on the County Hospital grounds. About $60,000. Binder & Curtis, 255½ South 1st St., Archts.

Cal., San Luis Obispo—W. B. Burch, Engr. will soon receive bids for pump with a capacity of between 450 and 500 gal.

Cal., Terra Bella—The Terra Bella Irrigation Dist., E. R. Clemens, Secy., will receive bids until Jan. 3 for furnishing 1 horizontal centrifugal pump, capacity, 5,000 gal. a min. against a head of 125 ft. to be direct connected to electric motor, 200 hp. 2200 volts, 60 cycles, 1,200 revolutions per min.

Que., Montreal—The Acadia Drug Ltd., 39 Vitre St., J. G. Magnan, Purch. Agt., is in the market for one 15 hp. steam boiler.

Ont., Caledonia—The Council, J. Senn, is having surveys made for electric lighting and power distribution system for the township. About $42,000. A. Wilson, 190 University Ave., Toronto, Engr.

Ont., Norwich—W. W. Avey plans to build a planing mill. About $25,000. Prices wanted on equipment including engine, boiler, and complete equipment for mill.

Ont., Petrolea — The Peninsular Sugar Co., F. H. Gubbard, Mgr., is having plans prepared for sugar refinery (part 2 and 4) 600 tons capacity. About $1,500,000. A. Owens, care of owner, Archt. and Engr. Noted Nov. 8.

Ont., London—The Bd. of Governors, D. S. Fox, Western University, is having plans prepared for three university buildings, including a steam heating system on North London St. About $2,000,000. W. J. Brown, Western University, Archt.

Man., Winnipeg — The Public Utilities Committe will receive bids until Jan. 9 at office of C. J. Brown, City Clk., for two kva., 3 phase, 60 cycle alternators for local service at the Point Du Bois power house. A. Caton, Chief Engr.

CONTRACTS AWARDED

Mass., Everett — The City Comn. has awarded the contract for a 4 story, 176 x 203 ft. high school on Bway. to G. F. Coburn, 294 Washington St., Boston, $425,500. Noted Sept. 27.

Conn., Meriden—The Meriden City Hospital, Cook Ave., has awarded the contract for a 4 story, 45 x 150 ft. hospital on Cook Ave. to H. Wales Lines Co., 134 State St. About $350,000. A steam heating system will be installed. Noted Nov. 1.

N. Y., New York—The Equitable Life Assurance Co., 120 Bway., has awarded the contract for a 20 story office bldg. on 7th Ave. between 31st and 32nd Sts. to Thompson Starrett, 49 Wall St. About $1,000,000. Noted Oct. 4.

D. C., Washington—The Potomac Elec. Power Co., has awarded the contract for a power plant to Stone & Webster, 147 Milk St., Boston, Mass. About $18,000.

N. C., Wilson—The Bd. of Trustees has awarded the contract for furnishing and installing heating and plumbing equipment in the new high school to J. L. Powers, Bennettsville, S. C., $25,463.50. Noted Nov. 8.

Ky., Louisville — The Natl. Candy Co., Federal Reserve Bank Bldg., St. Louis, Mo., has awarded the contract for a 5 story candy factory at 1456 West Bway., known as the F. A. Menne Factory, to the Struck Constr. Co., 147 North Clay St., $600,000. Steam heating system to the Neatherton Htg. Co., 111 North 5th St.

O., Akron—The Warranty Security Discount Co., 65 South High St., has awarded the contract for a 20 story, 65 x 70 ft. bank and office building on Main and Buchtel Sts. to W. Dunbar Co., 8201 Cedar Ave., Cleveland. About $1,000,000. A steam heating system will be installed. Noted Aug. 23.

O., Norwood — Kunz & Beck, Archts., Carew Bldg., Cincinnati, have awarded the contract for a 3 and 4 story, 232 x 354 ft. seminary on Norwood Heights, to the Ferro Concrete Co., 3rd and Elm Sts., Cincinnati. A steam heating system to Bromel Vapor Htg. & Electric Co. Total cost, $700,000.

O., Toledo—The Bd. Educ., Administration Bldg., has awarded the contract for a 3 story, 251 x 343 ft. high school on Western and Daniels Aves. to H. J. Spieker Co., Elm and Utica Sts. About $1,000,000. A steam heating system will be installed. Noted Nov. 8.

Wis., Fond-du-Lac—The Eastern Wisconsin Elec. Co., 15 North Main St., has awarded the contract for a 35 x 40 ft. substation to the Immel Constr. Co., 200 North Main St. About $25,000.

Wis., Green Bay—The Green Bay Investment Corp., 113 West Walnut St., has awarded the contract for a 3 story, 82 x 240 ft. cold storage plant on North Bway. to L. M. Hansen Co., 113 West Walnut St. About $250,000. Ice machine and refrigeration equipment will be installed. Noted Dec. 20.

Neb., Lincoln—The city has awarded the contract for furnishing equipment as follows: One 1,000 hp. economizer to Green Fuel Economy Co., 90 West St., New York City, $16,622; for two chain grate stokers for 500 hp. boilers and one open feed water, metering heater, for 4,500 lb. per hr. to the Kent Engr. Co., Omaha, total cost, $12,235; one superheater, 1,200 superheat for two 500 hp. boilers to the Power Specialty Co., 111 Bway., New York City, $3,450; two soot blowers to the Diamond Power Specialty Co., Kansas City, Mo., $922; one centrifugal driven boiler feed pump to C. H. Carr, Mchy. Co., 411 Mutual Bldg., Kansas City, Mo., $1,286; one hot process water softener, 2,000 gal. per hr. to the International Filter Co., 38 South Dearborn St., Chicago, Ill., $3,230. Noted Dec. 6.

Cal., Calwa—The Pacific Fruit Express Co., 65 Market St., San Francisco, has awarded the contract for an ice plant here, to D. R. Wagner, Call Bldg., San Francisco, $53,050.

Cal., Oakland—The Sanitary Ice & Storage Co., 26th and Chestnut Sts., has awarded the contract for a 1 story power plant on S.W. 26th and Linden Sts. to Nelson & Forsyth, Easton Bldg., $16,500.

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POWER

FRED R. LOW, *Editor*

ALFRED D. BLAKE, Managing Editor. THOMAS WILSON, Western Editor. WARREN O. ROGERS, FRANKLIN VAN WINKLE, F. A. ANNETT, F. L. BEERS, L. st. MORRISON, R. H. ANDREWS, P. W. SWAIN, Associate Editors. CHAS. D. FOLSOM, Jr., News Editor

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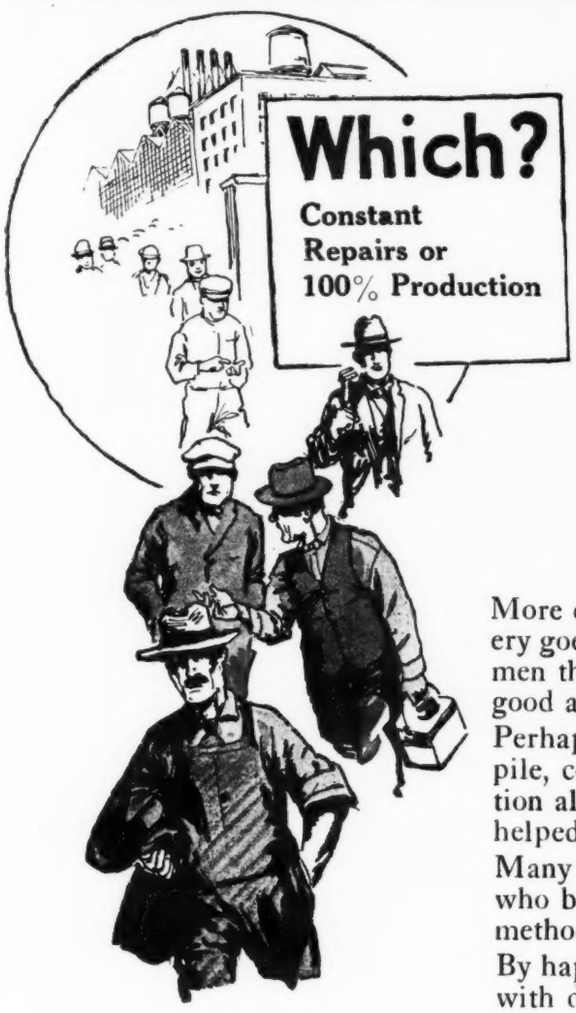
POWER

Wishes You

A Bright and Prosperous

New Year

THE DOMINANT CONSERVATION FACTOR



KEYSTONE Lubricants End Costly Shut-Downs

More expensive shut-downs occur—more valuable machinery goes to an untimely grave in the scrap pile because some men think that "grease is grease"—that one kind is just as good as another—than from any other cause.

Perhaps you consider these frequent processions to the scrap pile, costly repairs, shut-downs and slowing up of production all as a "part of the day's work"—things that can't be helped. *If so, this message is written especially for you.*

Many of our most enthusiastic boosters today are those men who but a few years ago were absolutely certain that their methods of lubrication could not be improved.

By happy experience, by an increased volume of production with decreased operating expense, longer life for valuable machinery and the elimination of costly shut-downs—they have proven that the Keystone Venango Gravity Grease System and

KEYSTONE GREASE

THE MASTER LUBRICANT

"Makes the Most Efficient Mechanical Unit MORE Efficient"

Our engineers have solved a multitude of the most difficult lubricating problems that have ever arisen in the attainment of high industrial efficiency.

It may be that a troublesome lubrication problem is causing you an endless amount of worry right now. Write us in full detail today—we'll give you the benefit of a lifetime of experience in the entire field of lubrication engineering.

Where Efficiency Counts and Is Measured —American Industries Move On Keystone Grease

KEYSTONE
TRADE MARK
Reg. U.S. Pat. Off.
GREASE
The Master Lubricant

THE KEYSTONE LUBRICATING COMPANY

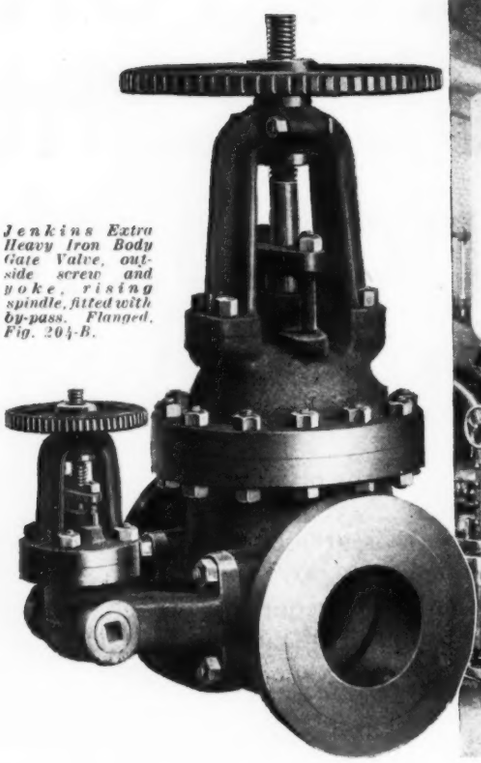
New York
Boston
Pittsburgh
Chicago
Detroit

Executive Office and Works
Philadelphia, Pa.
Established 1884

St. Louis
Denver
San Francisco
Minneapolis
Montgomery, W. Va.

Agencies in Principal Countries Throughout the World

KEYSTONE LUBRICANTS



Jenkins Extra Heavy Iron Body Gate Valve, outside screw and yoke, rising spindle, fitted with by-pass. Flanged. Fig. 204-B.

Jenkins fulfill every requirement in High Pressure Power Plants

Jenkins Extra Heavy Gate Valves are suitable for steam and hot water service of all kinds under heavy pressures and high temperatures, and are especially adapted to meet the requirements of modern high pressure power plants.

The life of a Jenkins Valve, even in severe service of this kind, is almost everlasting, for all parts are renewable and interchangeable. All valves, either stationary or rising spindle can be packed under pressure, when wide open.

In many of the largest and finest plants, the country over, Jenkins Valves have been adopted as Standard Equipment. This choice and policy is, at all times, an assurance of dependable and economical valve service.

The reputation and prestige of Jenkins Valves has earned for them nation wide distribution. They are sold at supply houses everywhere. The "Diamond Mark" and signature identify the Genuine Jenkins.

JENKINS BROS.

New York Boston Philadelphia Chicago
Montreal London Havana

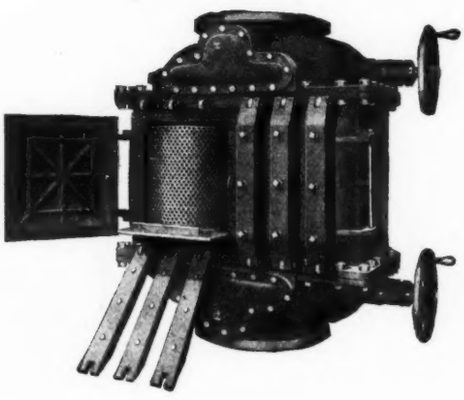
FACTORIES:
Bridgeport, Conn.; Elizabeth, N.J.; Montreal, Canada.

TWIN STRAINERS

Why should the water in your plant be "Twin Strained"

13 Good Reasons

1. Continuity of service. Twin Strainer baskets are cleaned without interrupting flow of water through strainer.
2. Reliability—nothing to get out of order.
3. Compactness—very little space required for installation. No foundation needed, simply placed anywhere in pipe line.
4. No moving parts—no attendance except occasional cleaning.
5. Practically no upkeep expense.
6. Easy to install in any position — vertical, horizontal or on an angle.
7. Made for suction or pressure service.
8. Easy to clean—anyone can do it, interior quickly accessible.
9. Large straining area as compared with inlet.
10. Introduces no undue head loss.
11. By using finer mesh, particles of any desired degree of fineness may be removed from the liquid to be strained.
12. No power required for operation, (except large motor operated type).
13. Heavily constructed throughout, equipped with bronze, copper or steel parts, as service requires. Parts exposed to water made of non-corrosive metal.



Sizes 1 in. to 42 in. Basket mesh to suit the service
Write for Bulletin "A," fully descriptive

A-69

ELLIOTT PRODUCTS
Condensers
Air Ejectors
Twin Strainers
Twin Filters
Feed Water Heaters
Steam Separators
Receiver Separators
Blow-Off Valves
Oil Filters
Steam Traps

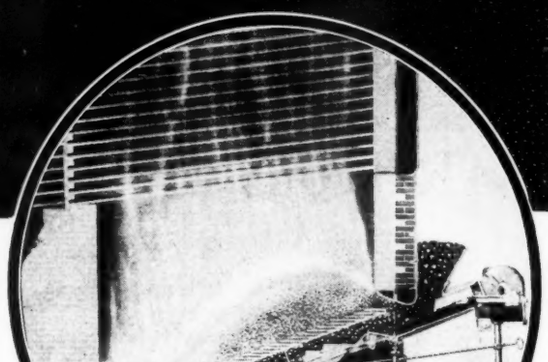
ELLIOTT COMPANY
Pittsburgh, Pa.
GENERAL SALES OFFICES, JEANNETTE, PA.
District Sales and Service Offices in Principal Cities

Is This You?

HORSE POWER

1921

Westinghouse Underfeed Stokers For Future Peak Loads



Between Peaks!

If your stokers need repair, between the peaks is the time to repair them. If your plant is not modern, now is the time to modernize. If your plant is hand-fired, now is the time to consider mechanical stoking.

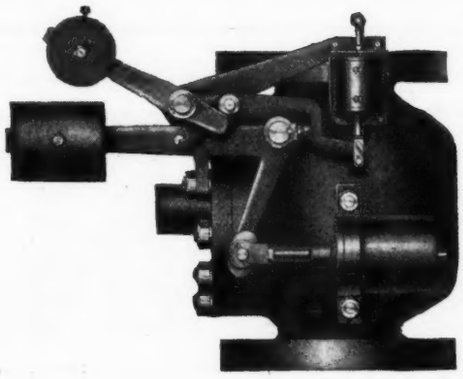
Do *now* what is to be done, for business revival has already begun and momentum is gathering.

Be among those who, perceiving the forward movement, find themselves ready when peak loads come.

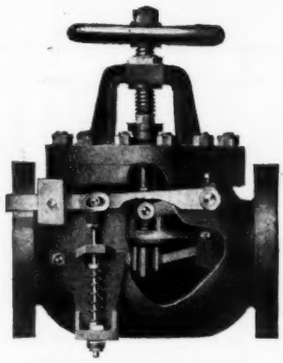
W
WESTINGHOUSE ELECTRIC

Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.
Sales Offices in All Principal American Cities

Westinghouse



Engine Stop



Non-Return Stop Valve

Preventing Disaster Is Simply a Matter of Foresight

Man has been using his intelligence for 500,000 years or more to outwit nature. In his battle with natural forces it was foresight largely that enabled him to survive. He now knows what certain forces will do under certain conditions and he circumvents disaster by eliminating elements of risk.

He knows that a runaway engine may result in a terrible flywheel explosion—and that the sudden reversal of steam flow into a damaged boiler may mean business for the undertaker at his plant.

The two "Strong" Specialties shown above are the most dependable automatic safety devices for guarding against just such contingencies. "Strong" Engine Stops automatically prevent accidents caused by overspeeding engines. Simply and scientifically designed. Absolutely sure in action. Centrifugal force for release and gravity for closure. Operates mechanically, but can also be controlled electrically from remote control stations. No engine is safe without one.

STRONG NON-RETURN STOP VALVES give absolute control from the outside—automatically and instantaneously. Steam is shut off whenever the pressure is lowered; giving protection to boilers, plant, and workmen in case of tube blowouts as well as preventing undue strain upon boilers that might lead to accidents. Corrosion and sticking of internal parts are impossible, and the outside operation renders them "foolproof." Can be installed in horizontal, vertical or angle position.

STRONG STEAM 4/S SPECIALTIES

THE STRONG, CARLISLE & HAMMOND CO. CLEVELAND, OHIO

"Strong" Specialties for safety and steam saving include Engine Stops, Non-Return Valves, 3-Way Emergency Valves, Traps, Separators, Pump Governor and Pressure Regulators, Boiler Feed Regulation, etc.

Mail the Coupon

The Strong, Carlisle & Hammond Co., Cleveland, O.

Gentlemen:—Please send me a copy of your latest Catalog No. 18-P at your earliest convenience.

Name .....

Address .....

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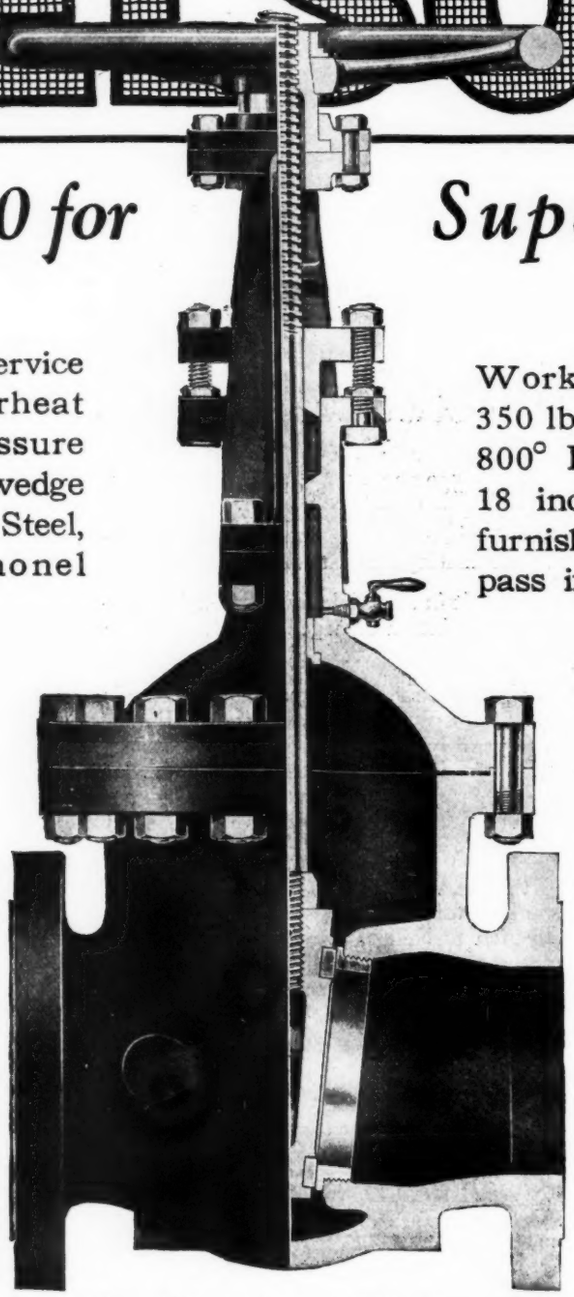
1922

12 27 20

NELSON

No. 1510 for Superheat



For unusual service on high superheat and high-pressure steam. Solid wedge construction. Steel, with full monel mountings.

Working pressure, 350 lbs. Good for 800° F. Sizes 2 to 18 inches. Can be furnished with by-pass if desired.

Remember the Number—Nelson Fifteen-Ten

NELSON VALVE CO.

ATLANTA—1311 Healey Bldg.
BALTIMORE—8 E. Lombard St.
BOSTON—131 State St.
BUFFALO—582 Ellicott Square
CHICAGO—650 West Lake St.
CLEVELAND—550 Kirby Bldg.

Chesnut Hill, PHILADELPHIA

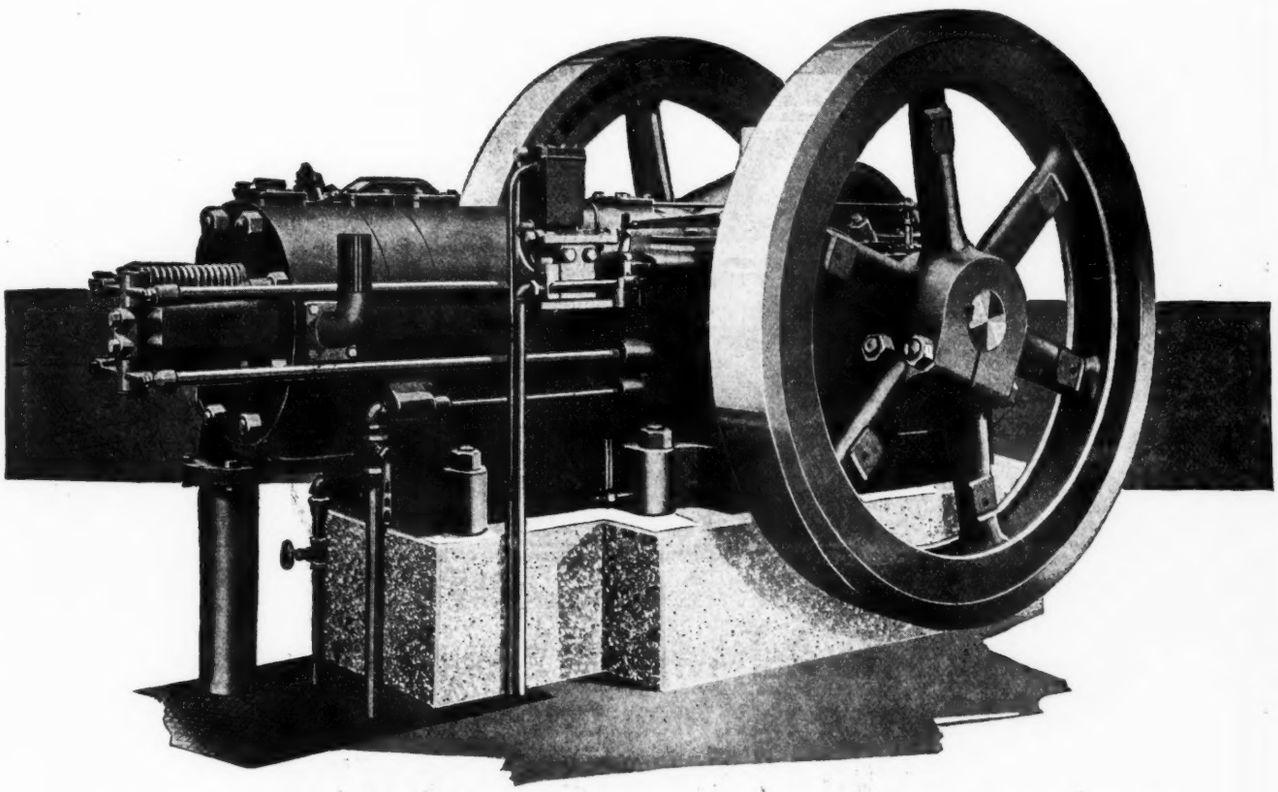
DETROIT—242 Larned St., West
NEW YORK—90 West St.
PITTSBURGH—517 Liberty Ave.
SAN FRANCISCO—75 Fremont St.
SYRACUSE—504 City Bank Bldg.

Price Type "PO" Oil Engines

These horizontal, single-cylinder engines are rugged, simple and compact.

Ignition is by temperature of compression—there are no hot bulbs or plates. No extraneous equipment is necessary for starting.

Fuel injection is direct and positive without the use of compressed air. With Price Engines no high pressure air compressor is necessary.



Guaranteed Fuel Oil Economy 0.45 pounds per brake horse-power hour at full and ¾ loads.

Guaranteed Lubricating Oil Economy one gallon per 4000 horse-power hours.

Let our engineers tell you all about Price Engines and how you can save money by using them for your power needs.

Ingersoll-Rand Co., 11 Broadway, New York

Offices the world over.

16-SOE

Ingersoll-Rand

"Huh! 'No Ash Wheelers Wanted'
I suppose that means they've installed
an AMERICAN-STEAM ASH CONVEYOR.
Well, they're saving money at that."

Literature on request.

CONVEYORS CORPORATION OF AMERICA
Formerly American Steam Conveyor Corporation

Chicago: 326 West Madison Street **New York: 110 West 40th Street**

AMERICAN
STEAM ASH CONVEYORS

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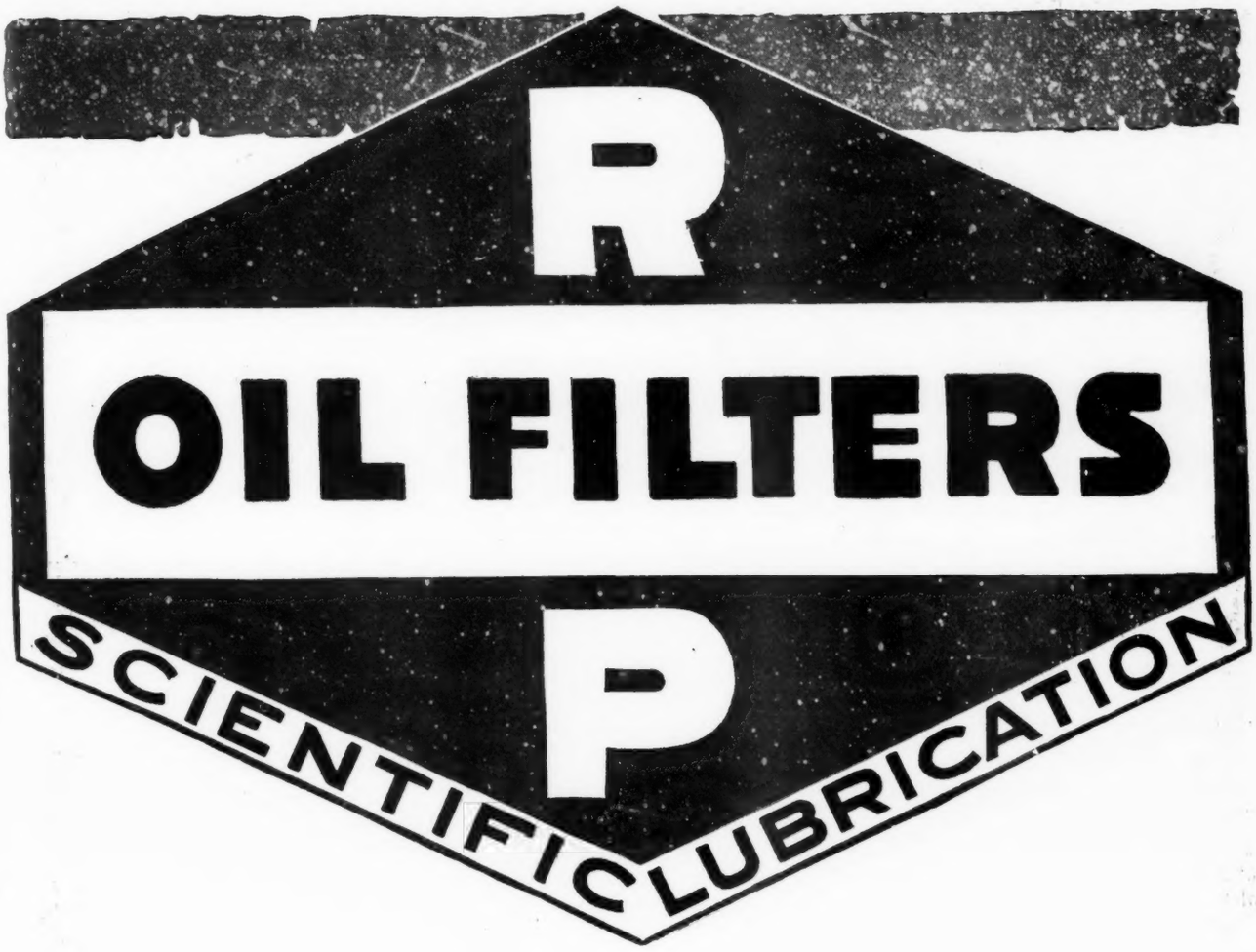


Whether Your Problem Is One of Lubrication, or Filtration and Reclamation of Lubricating Oil, R-P Engineers Can Solve It, Furnish the Equipment and Guarantee Results

Central Oil and Filtering Systems
Continuous By-Pass Systems for Turbines
Model T Force-Feed Lubricators
Oil Filters for All Classes of Service
Oil Reclaimers—all internal combustion engine oil
Fuel Oil Strainers for Boilers and Engines
Complete Marine Oiling and Filtering Equipment
Full Line of Oil Pumps

Individual Oiling and Filtering Systems
Hydro-Electric Oiling and Filtering Systems
Model M Force-Feed Lubricators
Sight-Flow Indicators
Centrifugal and Telescopic Oilers
Sight-Feed, Gang and Multiple Oilers
Cutting Oil Filtering and Sterilizing Systems
R-P Terminal Check Valves for Cylinder Oil Lines

Write for Literature on Equipment That Interests You

THE RICHARDSON-PHENIX DIVISION
S. F. BOWSER & CO., INC.
LUBRICATION ENGINEERS AND MANUFACTURERS
FORT WAYNE INDIANA

The New McClave M

Embodies the Advantages of Both Underfeed and Overfeed Principles

The new McClave Mechanical Stoker has a number of unique features of especial value to central stations and large power plants.

It is an "underfeed-overfeed" stoker, combining the advantages of both principles.

It is absolutely non-sifting.

It feeds coal by means of the McClave patented timing device. The same quantity of coal being pushed on the grates at each throw of the plungers, a fuel bed of uniform thickness is maintained.

Uniform combustion is easier to keep up and higher average efficiencies can be obtained at all ratings.

It can be brought from a "banked" position to 200% or 300% of rating in a few minutes.

The operating mechanism is simple, strong and compact, and it takes up a very small space in the firing alley.

Only Standard sizes of fire brick are required.

As the stoker is manufactured in its entirely in the McClave-Brooks plant, the quality and strength of every part is assured.

There are many more unusual advantages to this new McClave Underfeed-Overfeed Stoker. Write for complete information.

McClave-Brooks Company

Makers of the famous McClave Grates since 1883

Scranton, Penna.

New York, Philadelphia, Dallas, Syracuse, Charlotte, Jackson, Miss., Chicago, Detroit, Boston

The McClave Mechanical Overfeed-Underfeed Stoker

The McClave Mechanical Overfeed-Underfeed Stoker showing stoker grates and Ash Cut-Out Bars in their normal position, as well as the simplicity of the main stoker arch. This arch is designed so that only the regular plain straight fire bricks are used in its construction, thus eliminating the necessity for special arch brick.

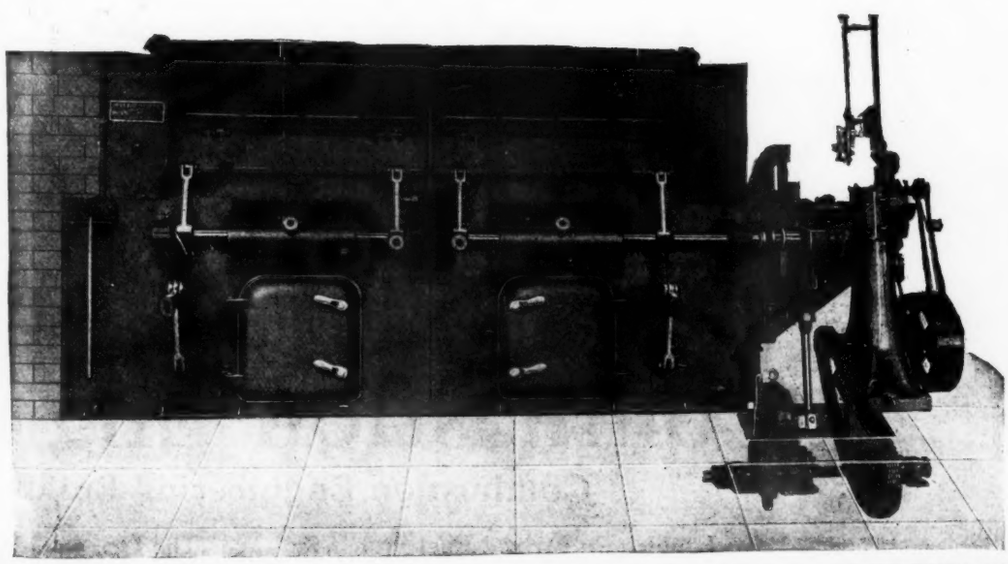
McClave COMBUSTION

e Mechanical Stoker

McClave

GRATES
STOKERS
STEAM
BLOWERS

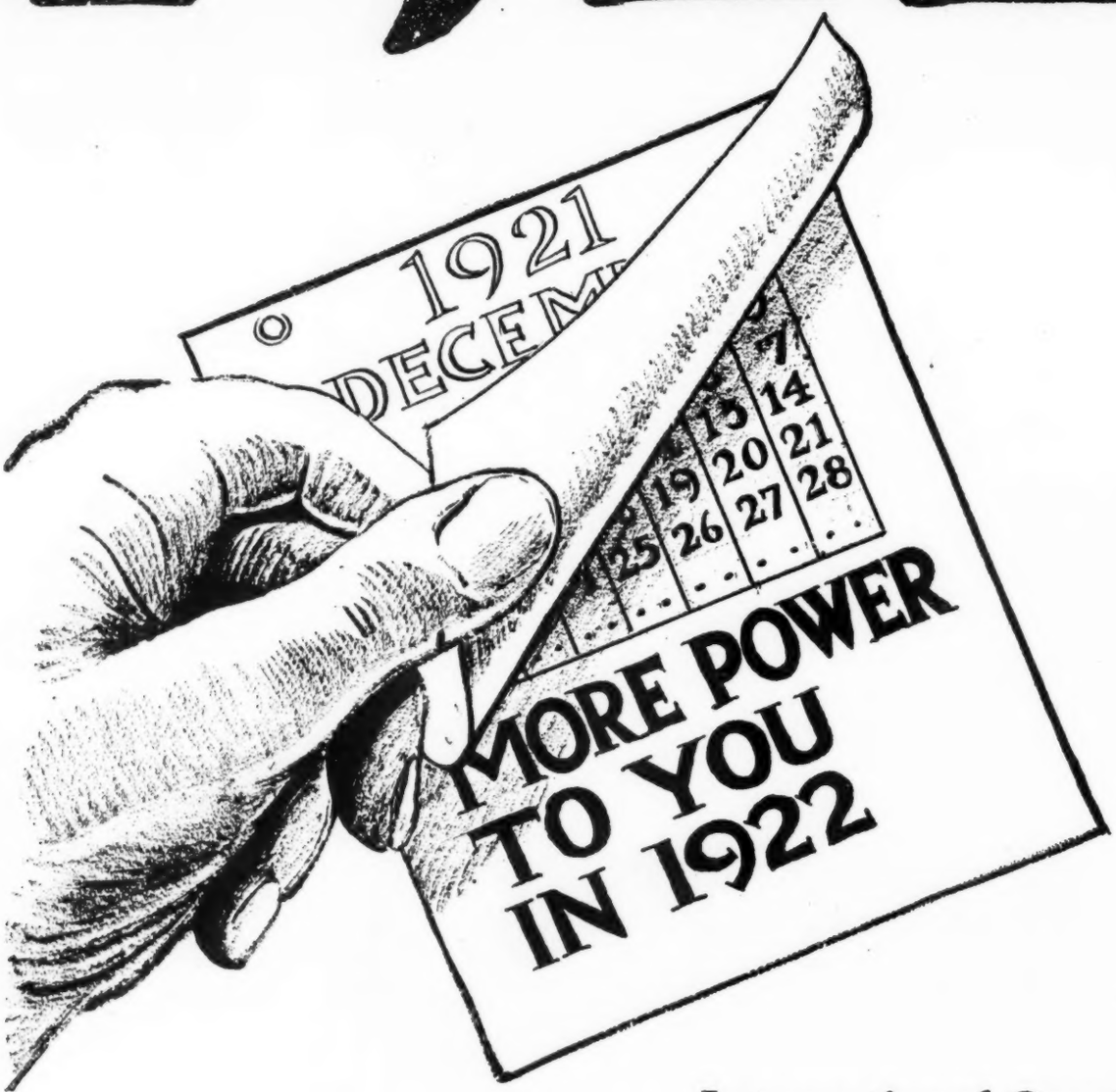
View of McClave Stoker with the Kicker Bars in differential and divided kicker movement. These Kicker Bars are so arranged that either one kicker; two kickers; or all of the kickers, either in one row, or in both rows, may be operated singly or differentially, as the conditions of fuel might demand. The Ash Cut-Out Bars are shown in normal position.



Note the very durable construction and extreme simplicity of design with a minimum of moving parts on the front of the Stoker. This type of drive is capable of operating either one, two, three or more Stokers.

SYSTEMS *for greater economy*

1922



International Combustion

Combustion Engin

Combustion Engineering Building,

Type E Stokers—for Bituminous Coal Lopulco Pulverized Fuel Systems The Grieve Grate–

PHILADELPHIA, PA. PITTSBURGH, PA. MINNEAPOLIS, MINN. BIRMINGHAM, ALA.
SEATTLE, WASH. ALBANY, N. Y. DETROIT, MICH. OMAHA, NEB.

TAYLOR ENGINEERING CO.

Reasons

for using

Coxe Stokers

are the men—owners, operators and consulting engineers—who know the many advantages of Coxe Stokers and are continually coming back for more.

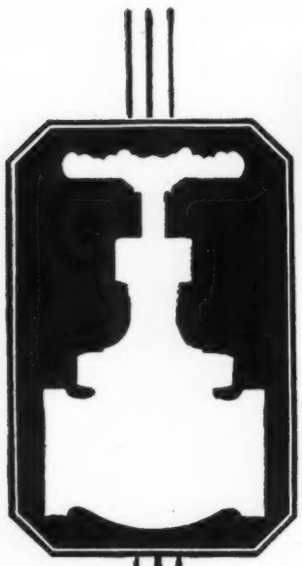
Engineering Corporation

eering Corporation

Broad Street, New York City

Hand-Firing Coxe Stokers—Anthracite Coal, Coke Breeze and Bituminous Coal

CHICAGO, ILL. BOSTON, MASS. HAZLETON, PA. SALT LAKE CITY, UTAH
DENVER, COLO. MILWAUKEE, WIS. ATLANTA, GA. CHARLOTTE, N. C.
VANCOUVER, B. C.



LUNKEN
"Renewo"

Specified by engineers seeking the highest degree of efficiency in operation and maintenance because *"Renewo"* service records are proof positive of their unparalleled value for power plant use.

Users realize there is no substitute for *"Renewo"* excellence,—their wear resistance, permanence in the line and low upkeep cost all contributing to economy—the essential to successful plant operation.

The broad scope of the line, including Globe, Angle and Cross, Straightway or Y, and Horizontal and Angle Check Valves, for pressures up to 200 and 300 pounds covers every requirement.

Carried in stock for immediate delivery by Lunkenheimer Distributors situated in every Commercial Center. Specify *"Renewo"* Valves and insist on getting what you specify.

Write for catalog No. 58 DB.

THE LUNKENHEIMER CO.
"QUALITY"
LARGEST MANUFACTURERS OF
HIGH GRADE ENGINEERING SPECIALTIES
IN THE WORLD
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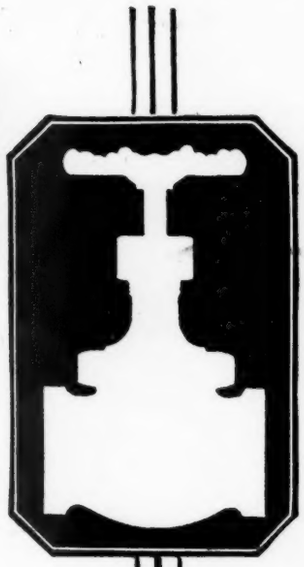
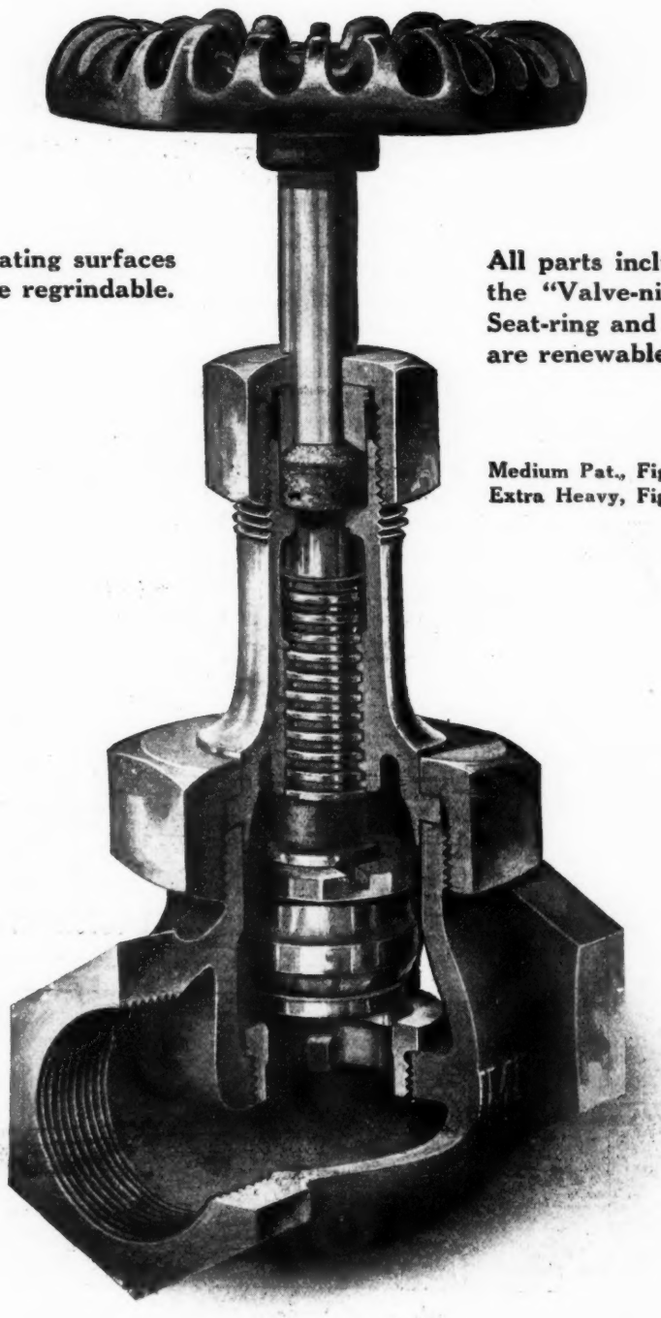
NHEIMER
o" *Valves*



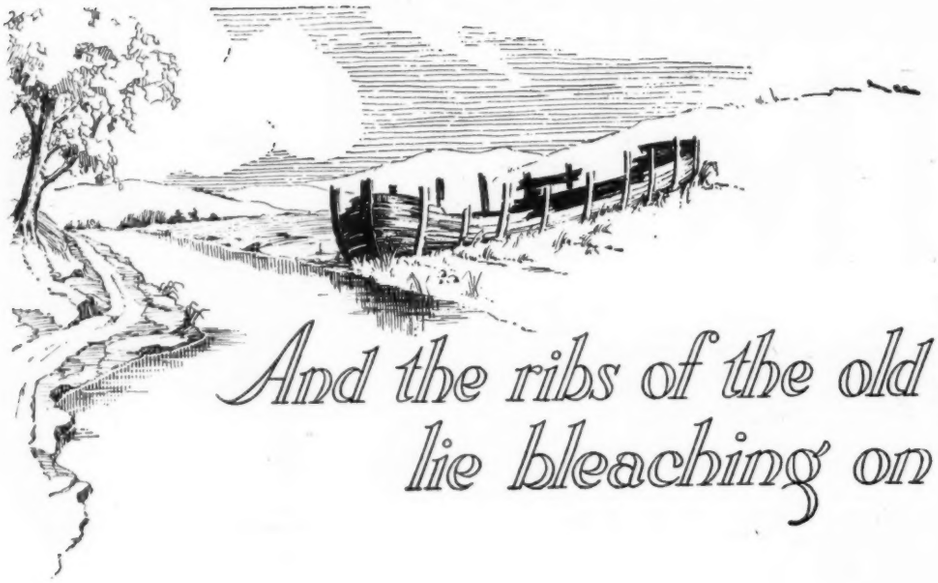


Seating surfaces are regrindable.

All parts including the "Valve-nickel" Seat-ring and Disc are renewable.

Medium Pat., Fig. 73.
Extra Heavy, Fig. 16.

AMERICA'S BEST
LUNKENHEIMER
QUALITY
SINCE 1862



And the ribs of the old canal boat lie bleaching on the bank

Gone is the trudging mule from the tow-path . . . the last echo of "low bridge" is stilled . . . and grim reminders of the past glory of the canal dot the banks of our waterways. The canal boat is as dead as Pharaoh.

Today a train of 50-ton "gons" hauls more coal than a fleet of canal boats. Does it at a fraction of the cost, quicker and without loss. Railroads have replaced canals.

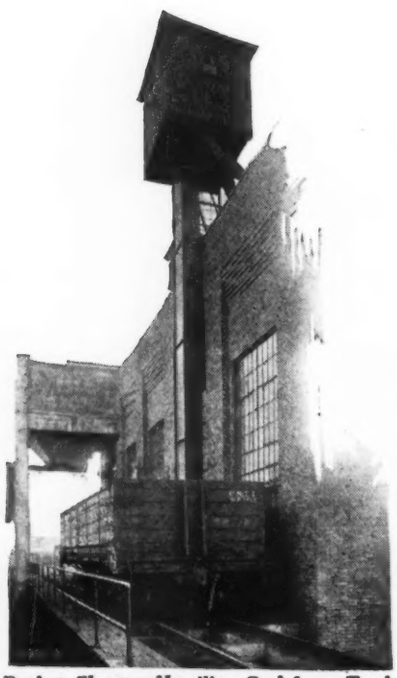
So it is in power plants; machinery has replaced men and mules. Conveyors carry coal to storage bins . . . to crushers . . . to stokers . . . and ashes from boilers to outside plants. Modern power plants are equipped with Jeffrey Coal and Ashes Handling Machinery in the interest of economy, efficiency and better working conditions. This includes Conveyors of various types, Chains, Bucket Elevators, Crushers, Weigh Hoppers, Skip Hoists, Electric Locomotives, Portable Bucket Loaders, Car Unloaders, etc.

Jeffrey expert Engineers will gladly assist you in the selection of the equipment needed to put your coal and ashes handling costs on an economical basis, as they have in hundreds of plants.

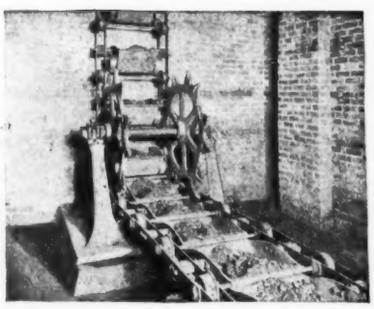
The Jeffrey Mfg. Co., Columbus, Ohio

St. Louis	Philadelphia	Chicago	Dallas	Pittsburgh
New York	Scranton	Buffalo	Middlesboro, Ky.	Denver
Boston	Cleveland	Charleston, W. Va.	Birmingham	Los Angeles
Detroit				Milwaukee

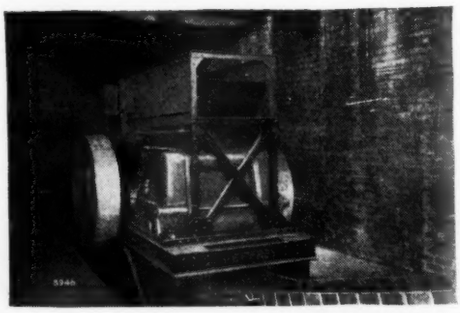
JEFFREY
MATERIAL HANDLING MACHINERY



Bucket Elevator Handling Coal from Track Hopper to Bunkers.



Lower Run of a Jeffrey Pivoted Bucket Carrier



Jeffrey Single Roll Coal Crusher Delivering Coal to Jeffrey Standard Steel Apron Conveyor.

Hancock Quality Applied To Gate Valves

Order one or more and compare them with any Gate Valve that you have ever seen

A Design Which Embodies All That Is Best In Modern Gate Valve Practice—

A design so good that the name "HANCOCK" can be put on it—a design that represents the last word in a Gate Valve for high pressure, high temperature service.

The Hancock Gate Valve is made with self-rising stem, yoke type bonnet, renewable seats and split wedge discs, either of bronze, nickel or monel, and with universal pressure packing gland. Bodies and yokes made of either the high grade temperature resisting bronze, which has made Hancock Valves famous, or of cast steel.

Hancock Gate Valves are all tested to 1000 pounds hydraulic pressure before shipment. They are made to withstand the most severe service to which a Gate Valve can be subjected.

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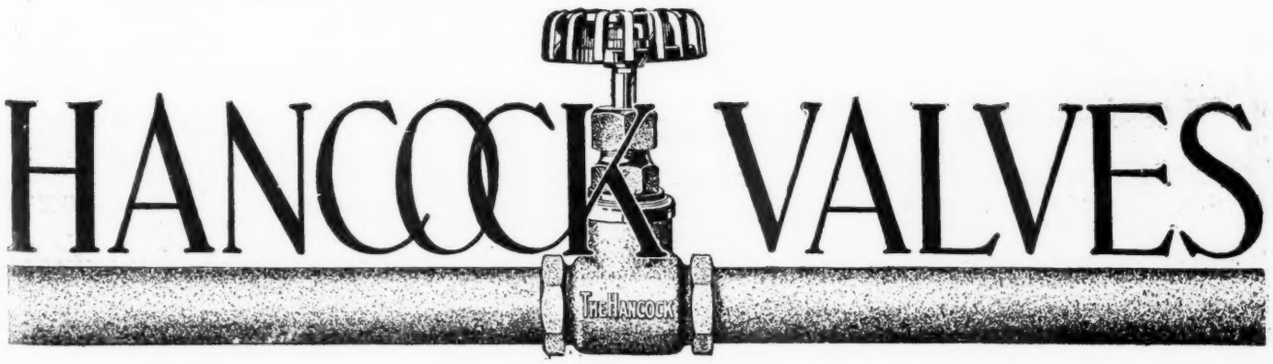
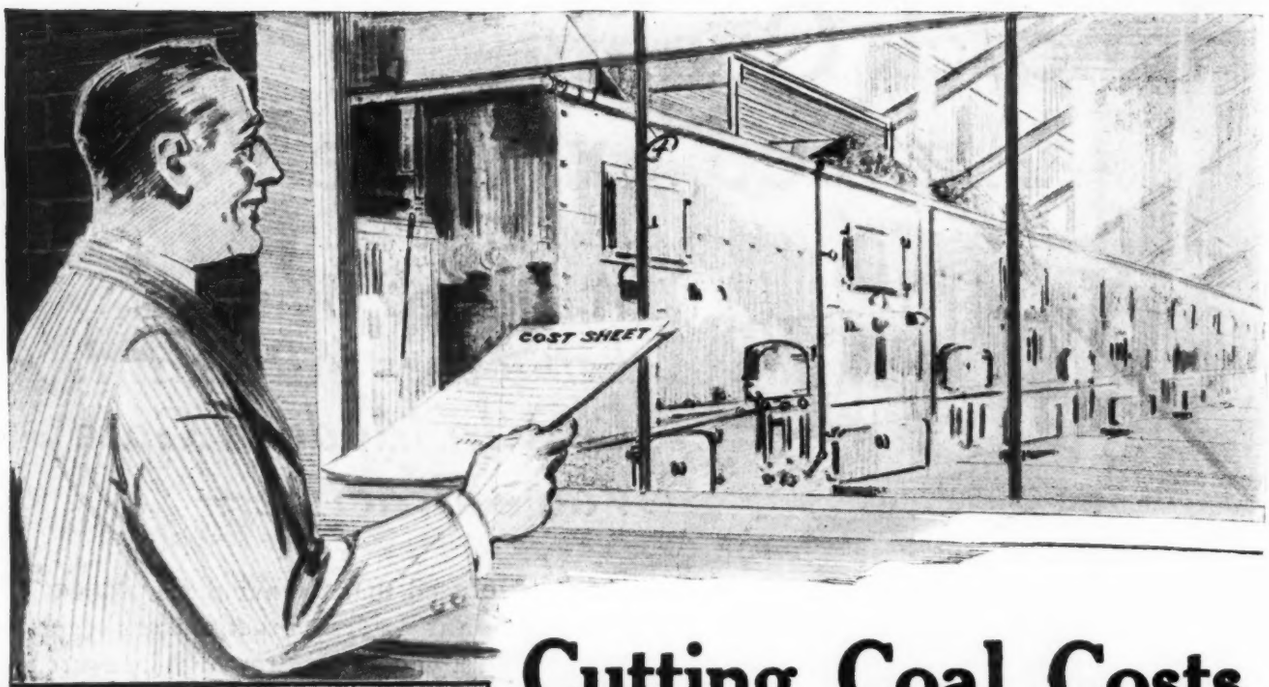
HANCOCK WORKS
119 WEST 40TH STREET, NEW YORK, N.Y.
DISTRICT SALES OFFICES Chicago, Philadelphia, Boston, St. Louis, Pittsburgh, Cleveland, New Haven, Cincinnati, Buffalo, Syracuse, Detroit, Milwaukee, San Francisco, Seattle
VALVES · INJECTORS · INSPIRATORS · SAFETY VALVES · GAUGES · CRANES · MACHINE TOOLS · SUPPLIES



HANCOCK VALVES

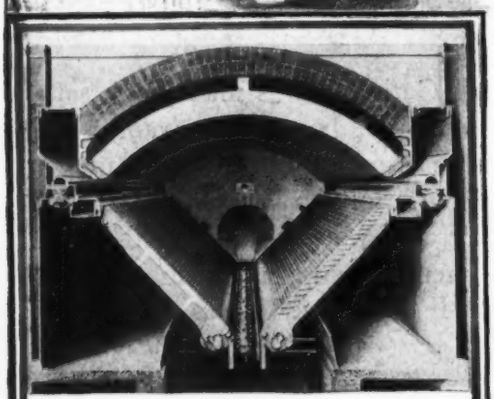


Cutting Coal Costs

For 44 years Murphy Furnaces have been saving coal and lightening labor for thousands of users in every section of the country. Many reports are being received such as this from a City Hospital saying that they *saved* from *seven to ten tons of coal per 24 hours* over previous hand fired conditions.

Here's why the Murphy is a fuel saver. It feeds the coal without opening the fire doors. The admission of cold air in large volumes is thus prevented; economy is secured and the life of the boiler is prolonged. The Murphy Furnace goes a step further. The fire is cleaned and the refuse removed automatically. This is a continuous operation and can be regulated to meet any condition. Every part of the fire chamber is visible and accessible. There is no periodic dumping nor drawing out of ashes, clinker, and incandescent fuel and coke, with resultant lowering of furnace temperature and steam pressure.

A request from you brings our Catalog P-12 describing the Murphy Furnace in full



Factors Back of Every Installation of MURPHY FURNACES

Natural Draft—on everything except the most extreme peak loads. Will double the output of your boilers without one penny for draft.

Standard—The Murphy Furnace is standard in design. In many instances the new features that have been developed may be applied to Murphy Furnaces now in use.

Smokelessness—The Murphy Furnace is designed to afford perfect combustion. The arch insures high furnace temperature which means that the air is preheated and admitted exactly where and when needed to give maximum efficiency.

Automatic Operation—The amount of fuel supplied may be regulated while in operation. Every detail for keeping a perfect fire is provided in the design and construction of the Murphy Furnace. The coal is supplied—the fire distributed evenly—the ash removed—continuously and automatically.

"A type to meet every stoker need"

SANFORD RILEY STOKER CO.
WORCESTER, MASS.
Makers of
RILEY UNDERFEED STOKERS
BOSTON NEW YORK CINCINNATI

TRADE MARK Rx REGISTERED

PHILADELPHIA CHICAGO PITTSBURGH ST. PAUL

MURPHY IRON WORKS
DETROIT, MICH.
Makers of
MURPHY AUTOMATIC FURNACES
BUFFALO CLEVELAND DENVER

Yarway Seatless Blow-Off and Double Tightening Valve

Yarway Unloader

Yarway Hydraulic Valve

Adjustable Sprayhead

1908–1922
Fourteen Years of Yarway Service

FOR nearly fourteen years The Yarway Products have been industriously making new friends—and strengthening those friendships by faithful service; now they can point to the record of promises fulfilled in thousands of plants throughout the world. Users of power plant specialties everywhere have endorsed the policy on which this business is founded—that of performing satisfactory service and giving full value. Their faith has been evidenced by the fact that five out of every six have repeated their first orders.

It is our hope and intention to merit the continued confidence of old friends and to have the privilege of making many new friends during 1922. May it be a prosperous year for you!

·YARNALL·WARING·COMPANY·
Mermaid Avenue
Chestnut Hill··Philadelphia
Representatives in all Principal Cities
For Complete List of Offices see Sweet's Engineering Catalog-Keystone Mining Catalog or Chemical Catalog

YARWAY SEATLESS BLOW-OFF VALVE YARWAY DOUBLE TIGHTENING BLOW-OFF VALVE YARWAY BOILER SKIMMER YARWAY ADJUSTABLE SPRAY HEAD YARWAY HYDRAULIC VALVE YARWAY UNLOADER YARWAY LEA V-NOTCH METER YARWAY PIPE CLAMPS ETC
YARWAY
POWER PLANT DEVICES

Yarway-Lea V-Notch Meter

Holtite Pipe Clamp (Stops holes and splits in pipes)

Yarway Pipe Joint Clamp

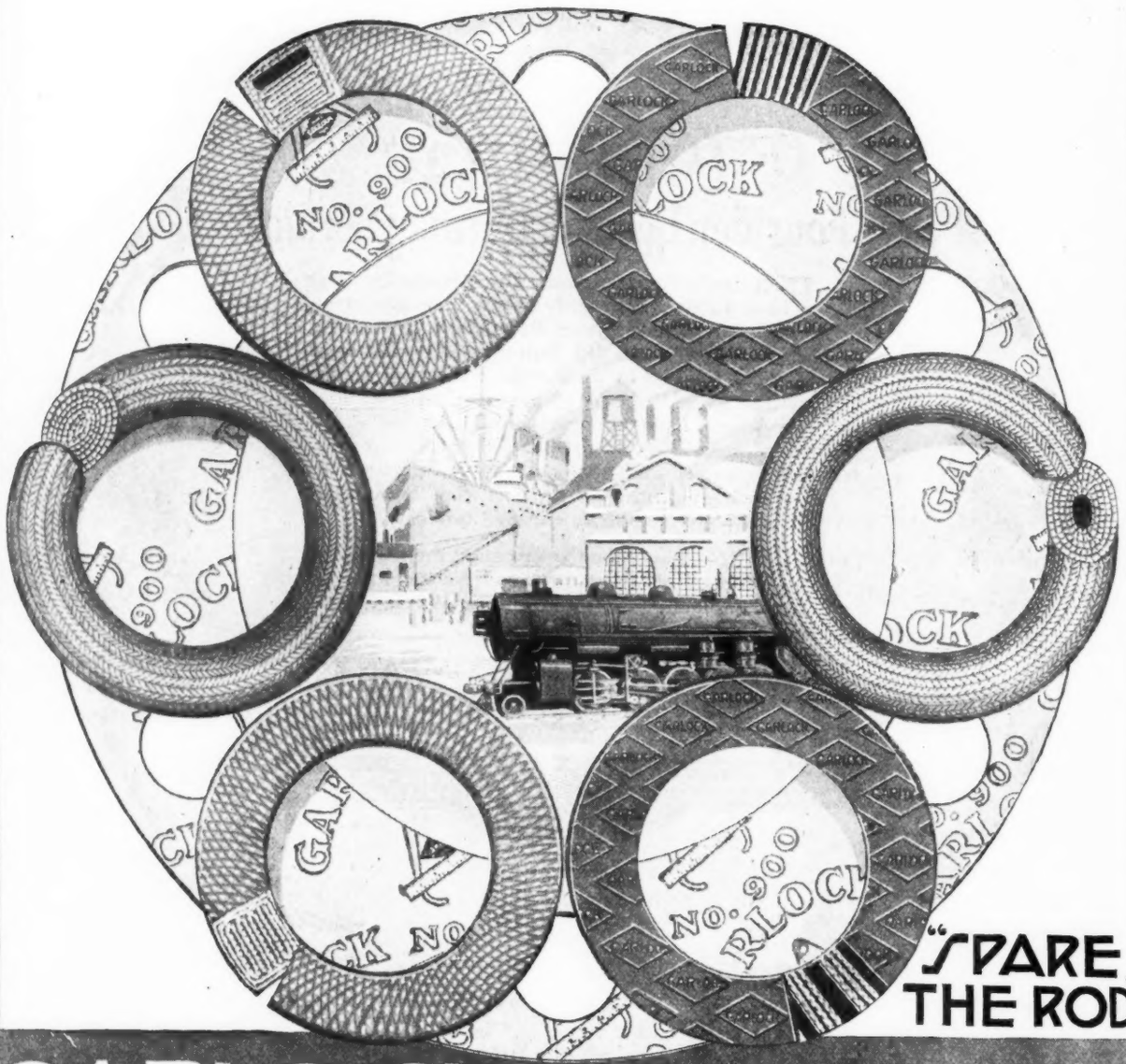
Yarway Boiler Skimmer

IN ENGINEERING CIRCLES

It Is the Operating Engineer Who Most Appreciates Reliability

Hours spent renewing rod packing and replacing gaskets, often in inaccessible places, have proven to him the fact that quality is the main consideration when purchasing packing. Added to this is the saving due to minimum rod friction and leakless joints.

On your next order specify GARLOCK, the packing of world-wide reputation and known reliability.



GARLOCK PACKINGS

THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK

BRANCHES:

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Chicago
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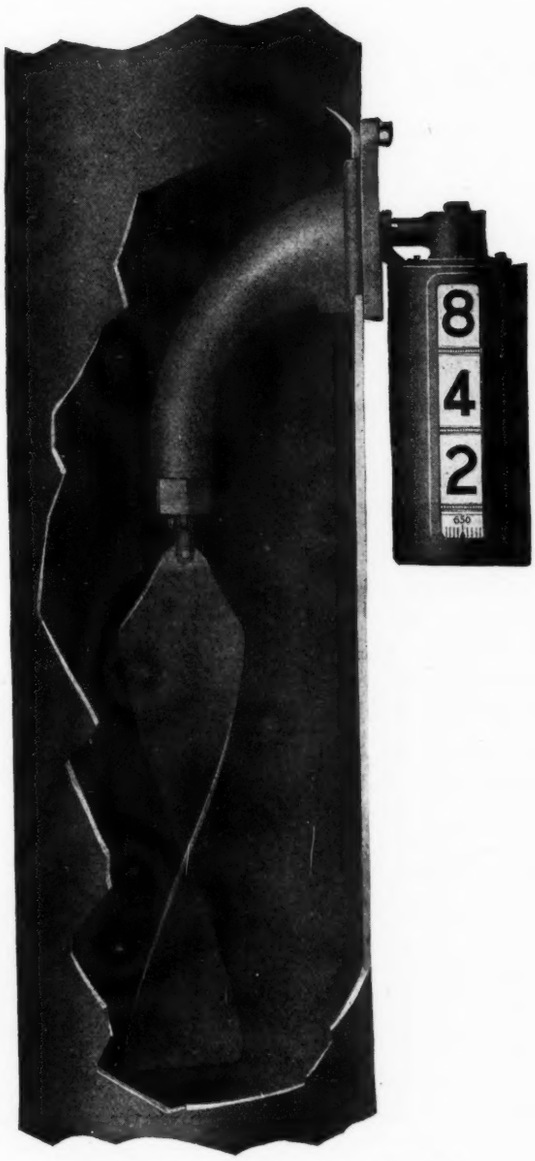
The True Coal Consumption of the Individual Boilers



Bailey Meter for Granular Material
Type V-2

is the basis upon which your plant economy depends.

It is not necessary to install extremely expensive and complicated weighing apparatus above each coal chute to obtain this important information.

THE BAILEY METER *for Coal*

Meets every requirement for accuracy.

Its operating principle is not new, but it has been mechanically perfected by the scientific design of the vane, the introduction of dustproof, universal ball-bearing suspension and in the transmission by flexible shafting, of the readings to an extra large self-illuminated counter, the figures of which can clearly be read from a distance of 50 feet.

When desired the counter may be located at any convenient distance from the vane.

Easily installed in existing coal chutes at a very moderate expense. Needs practically no attention in service.

Bulletin No. 220 gives full description.
Consult us regarding application to your boiler room.

Other Bailey Meters

Boiler Meters—
Recording Steam Flow, Air Flow and Flue Gas Temperature.

Fluid Meters—
for Steam, Water, Air, Gases and Vapors at any pressure or temperature.

Weir Meters—
for Water and other liquids.

Recording Tachometers—
for Stoker Speed, Paper Machines and other similar uses.

Specific Gravity Recorder—
for recording specific gravity of any liquid at any temperature.

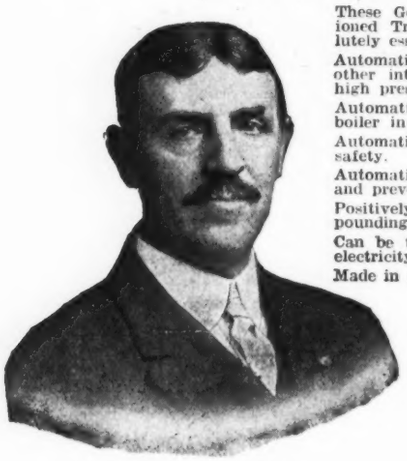
Multi-Pointer Gages—
for draft, steam pressure, etc.

Bailey Meter Company, 2011 E. 46th St., Cleveland, O.

Insure a Continuous Steam Supply—

Don't let a ruptured boiler tube interfere with the steam production in your boiler room. Safeguard yourself against disastrous backflow of steam and at the same time get full protection from pipe explosions in any part of your plant by installing

GOLDEN-ANDERSON
Life and Property Insurance Valves



CHARLES E. GOLDEN
President and General Manager

These Golden-Anderson Patent Automatic Double Cushioned Triple Acting and Non-Return Valves are absolutely essential in every power plant.

Automatically cut out a boiler when a tube bursts or other internal rupture occurs, preventing back flow of high pressure steam from the other boilers.

Automatically shut off the steam flow from every boiler in case any steam pipe bursts.

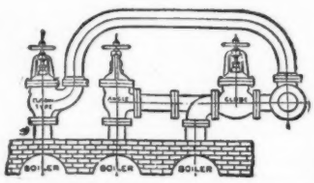
Automatically cut the boilers into the line with absolute safety.

Automatically equalize the pressure between all boilers and prevent steam from entering a cold boiler.

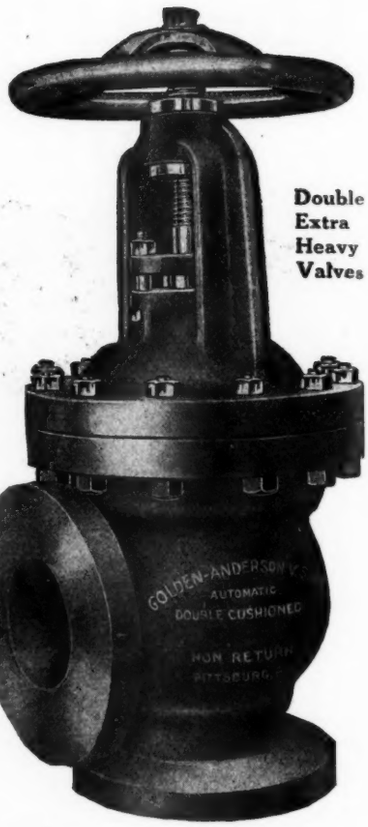
Positively cushioned by a double Corliss dash-pot. No pounding or sticking.

Can be tested in service. May be closed by steam or electricity from distant points.

Made in globe, angle or elbow pattern.

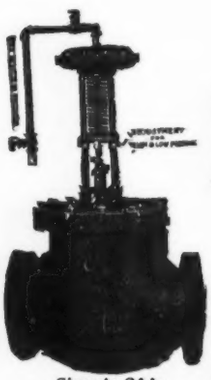


4100
Used by Steel Companies

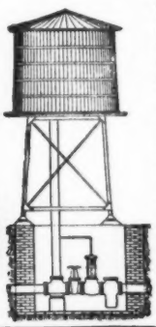


Double Extra Heavy Valves

GOLDEN-ANDERSON
Patent Automatic Cushioned Controlling Automatic Valves



Sizes to 24 in.



Automatically maintain a uniform stage of water.

Entirely self-contained. Operate without floats or fixtures.

Will work "both ways" on single pipe line by closing automatically in case pipe breaks.

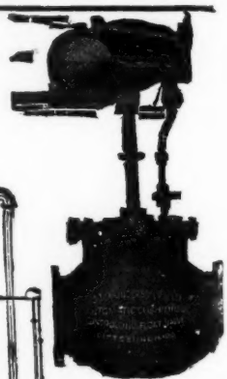
Perfectly cushioned by water and air.

Operate without water hammer, shock or metal-to-metal seating.

Can be closed from distant points by electricity.

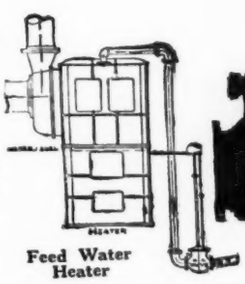
Sizes to 24 inches inclusive.

GOLDEN-ANDERSON
Patent Automatic Cushioned Controlling Float Valves



Especially Adapted for Maintaining Uniform Water Level in Feed Water Heaters, Tanks, Reservoirs, Vats, etc.

No Water Waste—Economic—Durable—Reliable—Air and Water Cushioned—Virtually Indestructible.



Feed Water Heater

GOLDEN-ANDERSON
Patent Automatic Cushioned Steam Pressure Reducing Valves

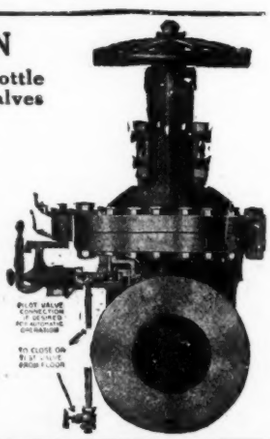
Safe Operating Piston makes it impossible for high pressure to enter into low pressure service. Makes accidents impossible. Thoroughly cushioned—no hammering, chattering or sticking.

No auxiliary valves or small by-pass—Reliable and uninterrupted service.

Double extra heavy throughout—Practically indestructible.

Only one adjustment—on the outside. Valve always accessible.

GOLDEN-ANDERSON
Pat. Cushioned Combination Throttle and Automatic Engine Stop Valves



Automatically tripped by overspeeding engine or turbine.

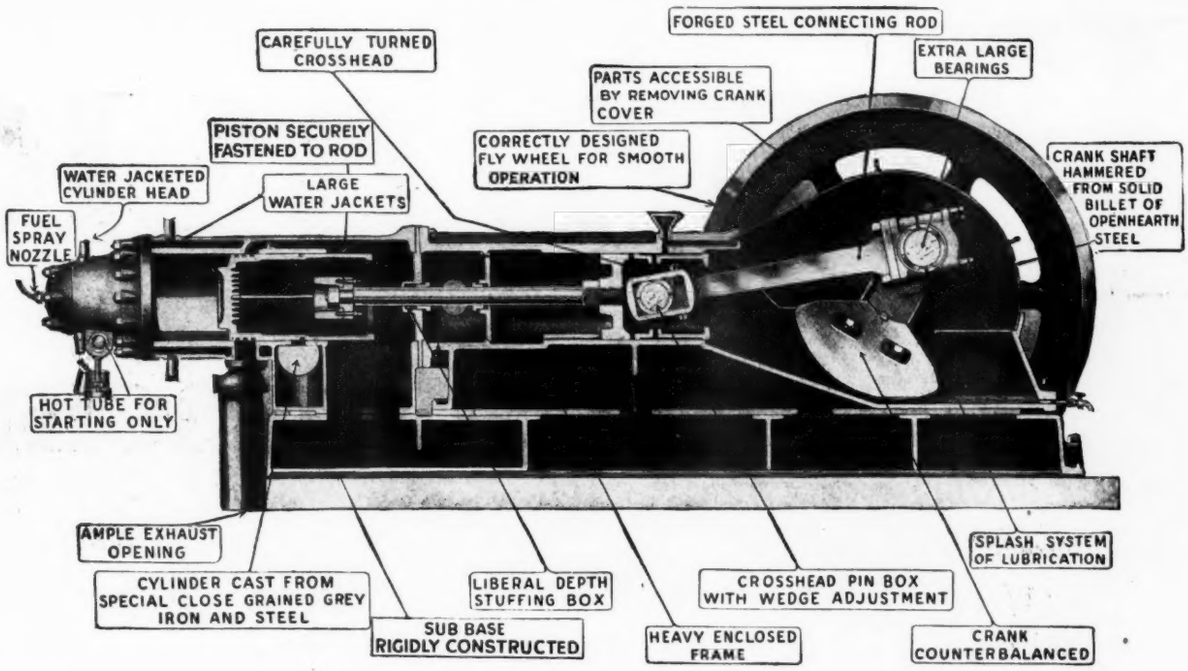
Electrically operated from distant points.

Emergency tripped by small branch pipe connection.

Hand operated by hand wheel. Double cushioned by Corliss dash-pots—positively no hammering or pounding.

Double extra heavy throughout—practically indestructible. Suitable for any pressure—no adjustments.

Golden-Anderson Valve Specialty Co., 1217 Fulton Bldg., Pittsburgh, Pa.


FORGED STEEL CONNECTING ROD
CAREFULLY TURNED CROSSHEAD
EXTRA LARGE BEARINGS
PARTS ACCESSIBLE BY REMOVING CRANK COVER
PISTON SECURELY FASTENED TO ROD
CORRECTLY DESIGNED FLY WHEEL FOR SMOOTH OPERATION
CRANK SHAFT HAMMERED FROM SOLID BILLET OF OPENHEARTH STEEL
WATER JACKETED CYLINDER HEAD
LARGE WATER JACKETS
FUEL SPRAY NOZZLE
HOT TUBE FOR STARTING ONLY
AMPLE EXHAUST OPENING
SPLASH SYSTEM OF LUBRICATION
CYLINDER CAST FROM SPECIAL CLOSE GRAINED GREY IRON AND STEEL
LIBERAL DEPTH STUFFING BOX
CROSSHEAD PIN BOX WITH WEDGE ADJUSTMENT
SUB BASE RIGIDLY CONSTRUCTED
HEAVY ENCLOSED FRAME
CRANK COUNTERBALANCED

The inside construction of Giants will bear as close scrutiny as their outside reputation

USERS have learned from actual experience that Giant Semi-Diesel Oil Engines stand alone on the basis of *dependability* and operating economy.

And the attendants of these engines have learned that Giants, due to their rugged simplicity, are practically independent of the human factor.

Giant Oil Engines are preferred because they possess the greatest number of *advanced* features of construction. This statement is confirmed by their inside construction features illustrated above.

Each feature shown does a *necessary* job in delivering power at lowest possible costs, contributing to an indefinitely long service life, every-day dependability, and operating simplicity that lessens attendant costs.

On a basis of year-in and year-out worth, fuel economy, lowered upkeep and attendant costs—how much can Giants save in *your* plant? How soon could a Giant pay for itself? If you wish, a C-P sales engineer will help you find out.

Ask for Bulletin 389.

Chicago Pneumatic Tool Company

Chicago Pneumatic Building · 6 East 44th Street · New York

*Sales and *Service Branches all over the World*

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EN43

BOYER PNEUMATIC HAMMERS··LITTLE GIANT PNEUMATIC AND ELECTRIC TOOLS
CHICAGO PNEUMATIC AIR COMPRESSORS··VACUUM PUMPS··PNEUMATIC HOISTS
GIANT OIL AND GAS ENGINES ROCK DRILLS·· COAL DRILLS

GIANT ENGINES

Dependable Power at *Less Cost Per Hour*

REPUBLIC

Announcing t

Combined Steamflow CO^2 Recorder only for Boilers

FLOW METERS

the Type S.F.C. Meter

The combined steam flow—CO_2 Republic Recorder provides the firemen with a positive and direct indication of the results they are getting from the work they are doing.

On its large open-faced chart—there are two pointers that register, automatically, steam flow and CO_2 percentages—The record is continuous 24 hours a day.

With this instrument on the boiler front you can expect and you will get, from your firemen, a higher boiler efficiency.

The position of the pen on the steam flow chart indicates to the fireman the capacity he is getting from the boiler, while the CO_2 record shows furnace efficiency at that particular rating.

It does not mean extra labor for the firemen—it means less labor.

The possible economy from the S. F. C. Recorder is practically unlimited—for it is a guide to saving rather than a means of saving.

Republic Sales engineers in our factory branches, located in all parts of the country, will be glad to call at your request and explain how the type S. F. C. Recorder will throw a light on the daily losses that go to make up such an amazing yearly total.

REPUBLIC FLOW METERS CO.
2240 DIVERSEY BOULEVARD
CHICAGO

New York Boston
Philadelphia Detroit
Pittsburgh Atlanta
Los Angeles

Portland, Ore. Denver
Minneapolis Seattle
Cincinnati San Francisco
Dominion Flow Meter Co., Canada

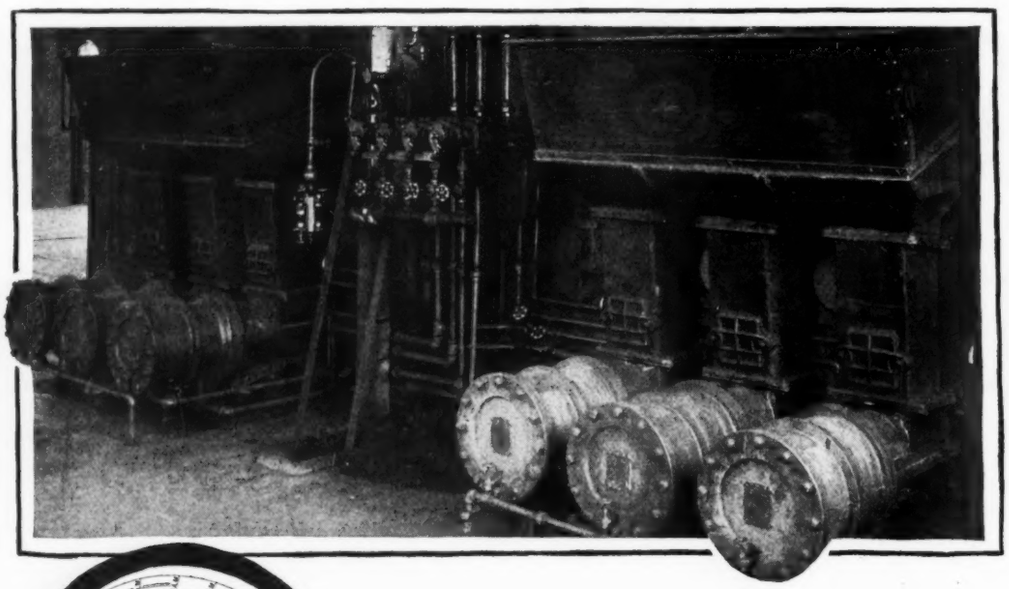
CLIP ALONG THIS LINE

REPUBLIC FLOW METER CO.
2240 Diversey Boulevard
Chicago, Ill.

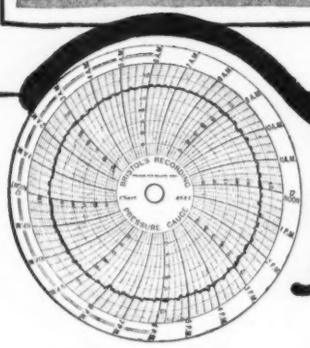
Gentlemen: We're interested in the combined flow meter—CO_2 Recorder (type S.F.C.) would like to have

☐ Catalog. ☐ Sales Engineer Call.

Name .....
Position .....
Firm .....
Address: ..... Power



Jones "A-C" Stokers installed at "Weiant Gardens" operated by W. S. Weiant & Son, Newark, Ohio. Note the Cole Automatic Valve in the center of the photograph.



Typical Pressure Gauge Record made in Jones Equipped Plant. Even Pressure was Automatically Maintained in Spite of Wide Variations in Steam Demand.

Made Possible by Automatic Control of Fuel and Air

One of the chief reasons for installing mechanical stokers is to insure even steam pressure regardless of load fluctuations. This is automatically taken care of in the Jones "A-C" Stoker by means of the Cole Valve, a patented device which automatically proportions fuel and air according to steam demand.

A steam pressure regulator is installed on the steam pressure line and this controls the engine (motor or turbine), driving the fan. When the steam pressure falls slightly the engine speeds up and this speeds up the fan, increasing the pressure and volume of air supplied the stoker. Conversely when the steam pressure drops the fan speed slows down.

The Cole Valve is driven by the fan and is installed on the steam line to the stoker cylinder. When the fan speed increases, it automatically accelerates the rate of action of the ram, thereby increasing the fuel supply. At the same time more air is delivered to the tuyeres, insuring complete combustion of the added fuel supply. When the steam demand recedes, the fuel and air supply is reduced in direct ratio to the decrease. The valve responds instantaneously to any fluctuation in the load, so that steam pressure practically never varies.

This important feature and nine other equally important features are covered in detail in the new book, "Ten Points of Jones Superiority," just off the press. Write for your copy.

Ten Points of Jones Superiority

Simplicity
Low Maintenance
High Efficiency
Automatic Cleaning
Prevention of Smoke
Prevention of Clinkers
Heavy Overload Capacity
Minimum of Moving Parts
Individual Control of Retorts
Automatic Control of Fuel and Air

The Under-Feed Stoker Co. *of America*

General Offices: Book Building, Detroit

Boston	Chicago	Dallas	Minneapolis	Omaha	Salt Lake City
Buffalo	Cincinnati	Denver	New Orleans	Philadelphia	Seattle
Charlotte	Cleveland	Kansas City	New York	Pittsburgh	Tulsa

The Under-Feed Stoker Co. *of Canada, Ltd.*, 81 Victoria Street, Toronto

Sole Manufacturers in the United States and Canada of the Jones Under-Feed Stoker

JONES "A-C" STOKERS

Do You Heat Your Feed Water?

If Not, or If So—

Send for This Book

It explains in detail the important features of the design of the Reilly Heater and why it should be used in your plant.

Every coil a spring—no expansion strains.

Coils attached to manifold by union joints, free from brazing.

Coils interchangeable.

Door in shell permits easy access to interior.

Compact—small space occupied.

Of Course You Will Want One To Reduce Your Steam Cost

Mail This Coupon Now

Name.....

Company.....

Address.....

The Griscom-Russell Co., 2116 West Street Bldg., New York City.

Send me at once without charge a copy of your Bulletin No. 260 on the Reilly Water Heating for efficient feed water for boiler feed or other purposes.

THE GRISCOM-RUSSELL COMPANY
2116 West Street Building, New York

Philadelphia	Toledo	St. Louis	Charlotte
Boston	Detroit	Denver	Salt Lake City
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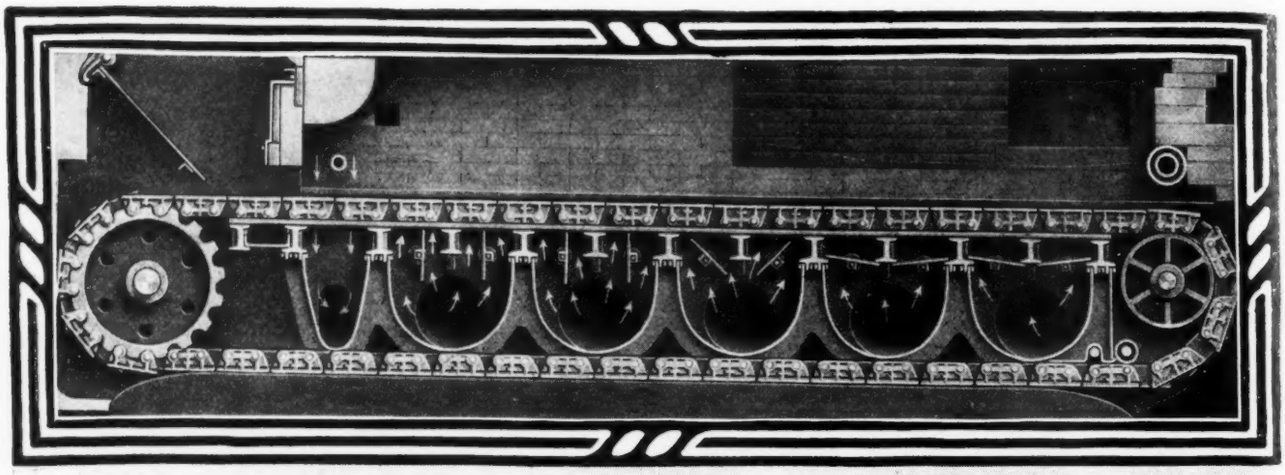


The Chain Grate Principle

Plus

Dampered Air Control

Air chambers located at regular intervals along the grate surface, and equipped with dampers, enable the operator to increase or diminish air supply at will. Where the fuel bed is thickest, as at the fuel gate, most air can be supplied. As the fuel bed becomes thinner the air supply may be reduced proportionately and finally stopped off where the fire is burning out. When operated to produce less than rated boiler capacity merely the distribution of the draft is changed and the ratio of the amount of air to the size of the fire remains the same. Therefore, the fire remains bright and snappy at all loads.

THE well-established success of chain grate stokers is a logical result of the basic advantages of the chain grate *principle* of stoker operation.

The still greater success of *Illinois* chain grate stokers is the outcome of many outstanding improvements that have been added to the inherent advantages of the chain grate principle by Illinois engineers.

Any chain grate stoker insures:

— total freedom from clinker trouble, even where highest ash fuels of stubborn clinkering tendency are burned.

— lowest labor costs, because of the entirely automatic cycle of supplying fuel, burning it, and discharging ash.

— lowest steam consumption for removing clinker formations and driving the stoker itself.

Isn't it well worth while to consider a stoker which preserves the time-tested chain grate principle and adds the refinements demanded by the highest standards of modern stoker firing?

Three of the more important features of the Type "G" Illinois Stoker are described briefly opposite—extensively in new Catalog "L."

ILLINOIS STOKER CO., *104 W. 7th St., Alton, Illinois*

Chicago: Ernest E. Lee Co., 115 S. Dearborn St. Kansas City: J. F. Pritchard & Co., 419 Reliance Bldg. Louisville: W. R. Wood, 601 Lincoln Bldg.

ILLINOIS CHAIN GRATE STOKERS

With Dampered AIR CONTROL

See branch offices at left.

Mechanical Ignition

Directly below the fuel gate in the Type G Forced Draft Stoker is a tuyere, operated under induced draft conditions, which draws a small amount of heated gases through the incoming fuels. This method of ignition—an exclusive Illinois feature—insures instantaneous ignition of lignite running as high as 45% moisture. By means of mechanical ignition anthracite culm and coke-braise—fuels notoriously difficult to ignite—can be fired to produce high capacity. The grade and kind of coal fired determines whether or not mechanical ignition should be employed.

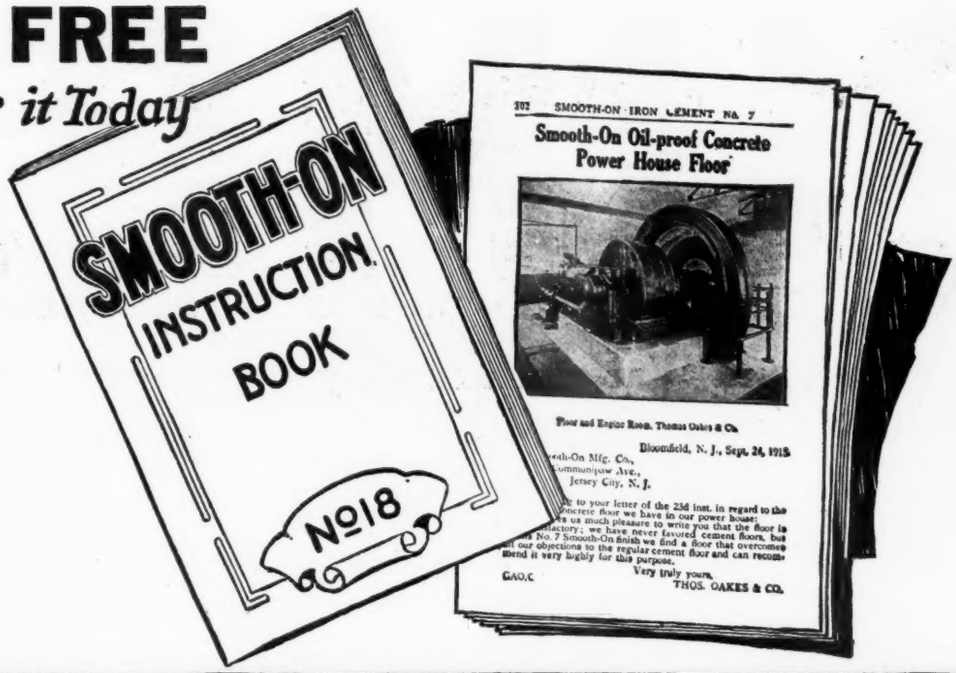
Forced Draft

For High Capacity

By means of mechanical or forced draft the Type G Illinois Chain Grate can be forced far beyond the limit of natural draft. The dampered air control system, in conjunction with forced draft, makes the Type G Illinois Stoker highly successful.

IT'S FREE

Send for it Today



SMOOTH-ON IRON CEMENTS

REG. U. S. PAT. OFF.

This Book is Ready for You

It's important to keep up-to-date in Smooth-On Iron Cement Instruction Books.

The latest one is No. 18 and it contains some interesting uses for Smooth-On Iron Cements that were not included in earlier editions.

Engineers are continually finding new uses in the way of boiler, engine room and general repair work and there is every reason why you should profit by their experience.

Send for Instruction Book No. 18 now.
You might forget if you put it off.

Wet Cellars

made dry from inside by coating the walls and floor with Smooth-On Iron Cement No. 7. Illustrated instruction book sent FREE upon request.

SMOOTH-ON MFG. CO.

Est. 1895

570-574 Communipaw Avenue
JERSEY CITY, N. J., U. S. A.

CHICAGO OFFICE: 221 N. Jefferson St.
SAN FRANCISCO OFFICE: 56 Sacramento St.

292

Smooth-On Mfg. Co.
Jersey City, N. J.

Gentlemen: Kindly send me a free copy of Instruction Book No. 18 as per your Dec. 27th advertisement in **Power.**

Name .....

Address .....

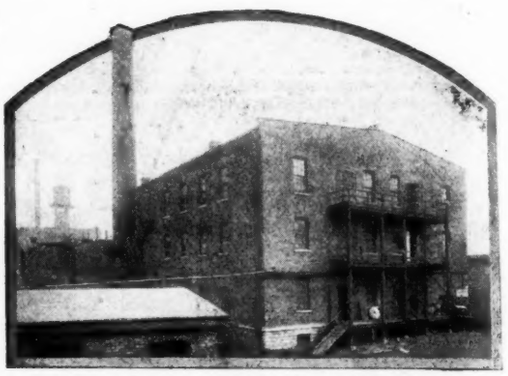
PUMPS

TRIPLEX · CENTRIFUGAL · ROTARY · DEEP WELL HAND

Pumping Oil and Water Alternately With a Goulds Centrifugal

One Goulds Centrifugal Pump in the S. Obermayer Co. plant, 18th and Rockwell Streets, Chicago, pumps oil and water alternately. Through the arrangement of the feed pipes, the loss of oil is reduced to the least possible amount. This Goulds Pump like all Goulds Pump installations gives satisfactory service—because every *Goulds Pump is guaranteed to perform satisfactorily the specific work for which it is sold.*

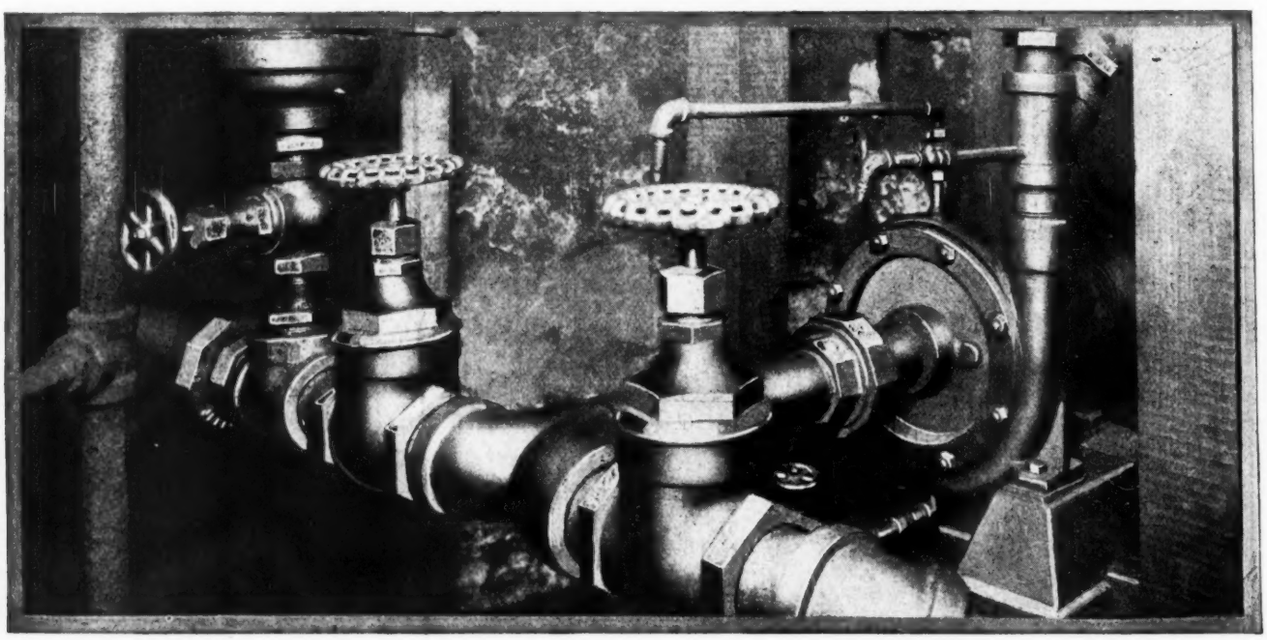
Our Engineering service department will be pleased to be of assistance to you on any pumping problem. Every engineer should have a set of our Bulletins—have you one?



Plant of S. Obermayer Co., Chicago, Ill.

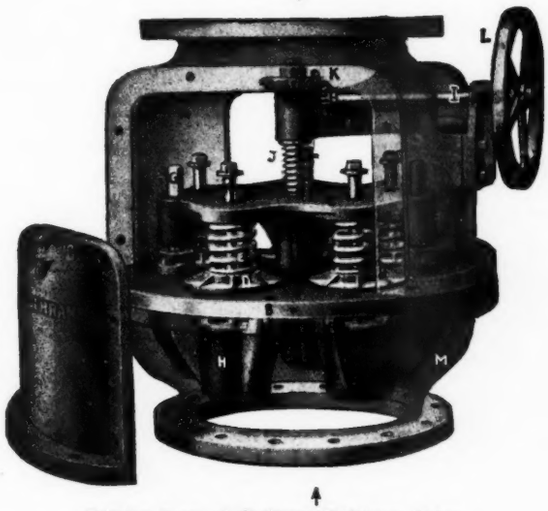
The Goulds Manufacturing Co., Main Offices and Works: Seneca Falls, N. Y.

New York, 16 Murray St., and 19 Park Place **Boston**, 58 Pearl St. **Pittsburgh**, 636 Henry W. Oliver Bldg. **Atlanta**, Citizens & Southern Bank Bldg.
Chicago, 12-14 S. Clinton St. **Philadelphia**, 111 North 3rd St. **Houston**, 1001 Carter Bldg. **Detroit**, 804 Dime Bank Bldg.



GOULDS

COCHRANE
MULTIPORT VALVES



Interior View of Cochrane Multiport Valve.

Excessive Back Pressure Wastes Money

LET us assume an engine developing 500 horsepower, which because of having a back pressure valve that is difficult of adjustment, carries 5 pounds needless back pressure for 5 hours during each of 200 days. Using steam at 100 pounds gauge and exhausting to atmosphere, such an engine would use 30 pounds per horsepower hour, but with 5 pounds needless back pressure the steam consumption would be increased about 4.8 lb. per horsepower hour. This is based on assuming the same percentage of increase as for a perfect engine. In a year, this waste would amount to 4.8 x 500 x 5 x 200 = 2,400,000 pounds. With an evaporation of 8 pounds of steam per, pound of coal and coal at $4.00 per ton the steam would be worth around $600.00, or much more than a Cochrane Multiport Valve would cost.

The facility which the Cochrane Multiport gives of changing the back pressure quickly and easily is also of value in connection with processes, such as paper making, etc.

With the Cochrane Multiport, the back pressure can be controlled from a distance, as by means of chains, rods, electric motor or hydraulic pressure. It is not necessary to climb up to the valve or to lift or shift heavy weights, as with the other types of valves.

Cochrane Multiport Valves are made for vertical, horizontal and angle pipes in all sizes.

Ask for our Multiport Valve book, giving types, sizes and methods of installation.

H. S. B. W.-COCHRANE CORPORATION

Formerly Harrison Safety Boiler Works

17th and Clearfield Streets, Philadelphia, Pa.

Also at Atlanta, Baltimore, Birmingham, Boston, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Greenville, South Carolina; Hazleton, Pa.; Houston, Indianapolis, Kansas City, Little Rock, Los Angeles, Minneapolis, New Orleans, New York, Pittsburgh, Richmond, Rochester, St. Louis, Salt Lake City, San Francisco, Seattle, Syracuse, Tucson, Toronto, Montreal, Halifax.

145

It's What the USER Says that Counts

THE METCALFE LAUNDRY
FRENCH DRY CLEANING
EAST SEVENTH ST.
PHONE 735
HOPKINSVILLE, KY. March 21, 1921.

Ever-Tyte Piston Ring Division,
Walter A. Zelnicker Supply Co.,
St. Louis, Mo.

Gentlemen:--

We regard the results obtained from the installation of Zelnicker Ever-Tytes in our Steam Engine and Boiler Feed Pump as A Number One.

We expect to install them in our motor trucks also.

Yours respectfully,

METCALFE LAUNDRY CO.,
By C. L. Morgan

Order on Trial
Save Fuel and Oil, Reboring
or send for more evidence
Ever-Tyte Piston Ring Division, St. Louis

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Leather Belting

The Belt that can stand the boiling test.

Tanners
Belt Manufacturers
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Tanneries:
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Branches and Distributors in All Leading Cities

Crandall Packing Co.
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Manufacturers of
Steam, Water, Air, Oil and Ammonia Packing in Ring, Spiral, Coil and Sheet Form
Boiler Gaskets and Pump Valves a Specialty

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New York	Denver	Birmingham	St. Louis
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All kinds of packing for all kinds of conditions

Don't Overlook Opportunities

Men who regularly keep in touch with the market through other channels often overlook the many opportunities that are to be found in the

SEARCHLIGHT SECTION
For Every Business Want
"Think SEARCHLIGHT *First"*

0156

The Original
Tripp Metallic Packing
Manufactured Solely by
WM. B. MERRILL & CO., 3188 Washington Street, Jamaica Plain, Boston, Mass.

Advertisements for the
Searchlight Section

Can be received at the New York Office of Power until 10 a.m.

Wednesday

For issue of the following Tuesday

71

Compare Them

The faint light of a candle and the strong rays of a searchlight. They represent the comparative efficiency of other ways of finding what you want and advertising for it in the

SEARCHLIGHT SECTION

Employment Equipment Business Opportunities

613

Your pumping requirements may be severe but—

there is a Warren pump that will meet them. And through its use you will enjoy a freedom from the troubles you may have experienced in the past. Low maintenance costs and high efficiencies are characteristics of Warren pumps.

Warren Steam Pump Company

Main Office and Works

Warren, Mass.

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CHICAGO
PHILADELPHIA

2100 fine tools are described and illustrated in the new Starrett Catalog No. 22 AG. Sent free on request. Write for copy.

Two generations of skilled machinists have learned to know Starrett Tools and to trust them.

Under the tuition of these men, thousands of apprentices are today learning for themselves the superior value in every Starrett Tool. No more conclusive evidence of quality could be asked than the marked preference for Starrett Tools shown by these men, to whose livelihood the selection of good tools is an essential matter.

THE L. S. STARRETT COMPANY
The World's Greatest Toolmakers
Manufacturers of Hack Saws Unrivalled
ATHOL, MASS.

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Starrett Tools

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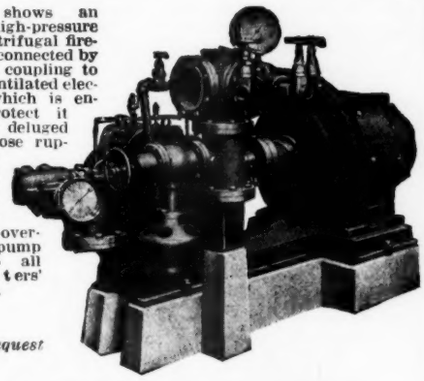
TRADE MARK REG. U.S. PAT. OFFICE.
CENTRIFUGAL AND DEEP WELL PLUNGER
PUMPS

A Dependable Fire Pump

Illustration shows an *American* high-pressure two-stage centrifugal fire-pump, direct-connected by flexible shaft coupling to high-speed ventilated electric motor which is enclosed to protect it against being deluged in case of hose rupture. There is also a safeguard against motor burning out from overloads. This pump conforms to all underwriters' specifications.



Catalog on request

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FIRST NAT. BANK BLDG.

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DIRECTORY:

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Julian S. Simsohn
New York Testing Lab.

Electrical Engineering
Wm. A. Baehr Org.
Electrical Testing Lab
Horner & Wyatt
Andrew Kidd, Jr.
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New York Testing Lab
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Specializing in Public Utilities Management, Operation, Construction, Plans, Reports, Valuation, Rates, Public Relations, Accounting, Purchasing
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Oil and Tar Burning Equipment which will burn oil or tar in combination with, or without coal
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Consulting Engineer. Power Plant Efficiency
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CARY, Albert A.
Power Plant Equipments
Designed, Reconstructed or Tested to Produce the Most Efficient Operating Results
Furnaces Designed
and Developed for Use of All Kinds of Fuel
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Relating to Power Plant Investigations
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Consulting, Designing, Detailing for the Engineering Trade. Specializing in Elevating, Conveying and Coal Handling Machinery Equipment. Steel Mill Buildings, Tank and Plate Work.
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Mill Engineer and Architect
Industrial Buildings, Textile Mills, Factories, Power Plants
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Inspections, Tests—Materials and Supplies
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Consulting, Design, Reconstruction and Installation of Special and Automatic Machinery, Electrical, Mechanical and Thermal Appliances.
160 5th Ave. New York City

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Power Plants — Industrial Plants
Plans, Specifications and Supervision
Reports, Appraisals and Rate Investigations
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Consulting Engineers
Industrial and Power Plants
Chemical Plant and Oil Refinery Specialists
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Consulting Engineer
Power Plants, Industrial Plants, Mechanical Refrigeration, Ice Plants. Construction, Installing, Supervision, Inspection, Tests, Reports.
Philadelphia, 4920 N. Warnock St.

MAIN, Charles T.
Industrial, Hydro-Electric and Steam Power Plants. Development, re-organization and valuation.
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MEYER, STRONG & JONES, Inc.
Power Plants—Mechanical and Electrical Equipment—Heating and Ventilating
101 Park Ave., New York City

W. E. MOORE & CO., Eng'rs
Electric Power and Industrial Plants
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Development, Design, Supervision
Union Bank Bldg. Pittsburgh, Pa

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Tests
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Specialists in water, steam and electrical power economy.
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Power Plants, Industrial Plants, Mechanical Refrigeration, Ice Making, Reports, Specifications, Tests and Appraisals.
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of having your name and service appear in this Directory is that the announcements are so grouped that those in need of professional assistance can find the service they need quickly and the organization best able to render it.

The cost is small — Write for rates

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EMPLOYMENT

POSITIONS WANTED

POSITIONS VACANT

New York

WANTED, machinery salesman with thorough acquaintanceship in the trade of New York City and vicinity, for position as manager of heavy machinery branch house. Only men of highest grade, technically trained considerd. P-873, Power.

EMPLOYMENT SERVICE

EXECUTIVES qualified for salaries of $2,500 to $25,000 and upward, are invited to communicate confidentially with the undersigned, who will conduct preliminary negotiations for such positions. A procedure is used which places you in the position of being approached, avoids jeopardizing present connections, and conforms to the most exacting personal and ethical requirements. Of particular advantage as a test of conditions, to determine the advisability of changing. Details mailed confidentially on receipt of name and address only, without obligating or committing you in any way. Established 1910. R. W. Bixby, Inc., 306 Lockwood Building, Buffalo, New York.

POSITIONS WANTED

Michigan

MECHANICAL Engineer, technical graduate, 14 years' experience in the manufacture and sale of boilers, stokers and general power plant equipment, desires position as sales or combustion engineer or boiler shop superintendent. Moderate salary. No preference as to location. Available Jan. 1st. PW-875, Power, Leader News Bldg., Cleveland, O.

New York

ENGINEER, 39, education, experience and record. Responsible central-station position preferred. Available anywhere on short notice. PW-874, Power.

EXECUTIVES

seeking superior positions find our confidential service extremely satisfactory. Let our Mr. H. H. Harrison confidentially negotiate for you suitable positions with proper employers, as he has successfully done for thousands of others since 1909. Inquiries invited.

THE NATIONAL BUSINESS BOURSE
Confidential Negotiators
Association Building, Chicago

SUPERINTENDENT
For Electric Light and Power Plant

serving a city and suburbs of about 40,000 inhabitants. Must be a high-grade engineer with executive ability and experience. Applications must state experience, salary expected and give references.

P-872, Power
1570 Old Colony Bldg., Chicago, Ill.

WANTED
A Graduate
Electrical Engineer

with proven ability to design, construct and operate. He should have commercial sense, even if without commercial experience, and ability to analyse and write technical articles for publication. Ability to write English and Spanish necessary. Give all your experience even if in a different field.

P-866, Power
10th Ave. at 36th St., New York City

POSITIONS WANTED

Ohio

GRADUATE mechanical engineer, six years' experience design, construction and operation of industrial power plants, heating and ventilating systems, factory maintenance. Know how to save the dollars in your steam plant. Go anywhere. A-1 references. PW-876, Power, Leader News Bldg., Cleveland, O.

Pennsylvania

STEAM engineer, 12 years' experience in the design, operation and maintenance of power plants. Steam and electric technical education. Ohio State license. Desire position as boiler room foreman, assistant chief or chief engineer. Available first of year. Location immaterial. PW-857, Power, Real Estate Trust Bldg., Phila., Pa.

Rhode Island

GRADUATE, combustion and steam engineer, 10 years' experience boiler rooms, corliss engines, turbines, electricity. Ohio license; go anywhere. PW-869, Power.

AGENTS AND SALESMEN

Representatives Wanted

To sell our Interlocking Sectional Tile Baffles to Stirling boiler users. Good proposition. Power Plant Efficiency Company, Indianapolis, Ind.

Salesman

"AL-HO-MO" boiler compound. Experienced preferred. Greatest and most effectual treatment known. Never fails. Wonderful repeater. Power plants, mills and factories buy on sight. Unlimited possibilities. Right man can earn $100 to $150 a week. Interesting proposition. Exclusive territory. Liberal drawing account. Franklin Refining Company, 329 First Ave., Pittsburgh, Penna.

Sales Engineer

Required to cover Ohio, for leading firm of power plant specialty manufacturers. Location, Cleveland. Only men who have several years' successful record in selling to power plants, machinery manufacturers and the mill supply trade need apply. Some technical training or practical experience an advantage. Salary, expenses and bonus paid. Applications must state training, experience and income desired. AS-877 Power.

Sales and Industrial Engineers

and power plant equipment men wanted, to sell a well advertised boiler setting elastic cement made of mineral rubber and asbestos fibre which is applied to the outside of brick settings. Prevents infiltration of air. Saves fuel and pays for itself in short time. Highest quality goods on market today. Our guarantee protects salesman and buyer. Exclusive territories now open. Excellent proposition to live wires. AS-858, Power.

Sales Engineer or Representative

One who is calling on power plants in Boston, Mass., and vicinity, Buffalo, N. Y., and vicinity, to sell on commission as side line high grade article that is needed and wanted by every power plant. AS-862, Power, Real Estate Trust Bldg., Phila., Pa.

Salesmen

Actively visiting power plants in Middle West and Central States. Old, advertised, favorably known line; large commissions. AS-590, Power, Old Colony Bldg., Chicago.

Salesman Wanted

One who is calling on power plants in any part of Pennsylvania, New Jersey, Delaware, Maryland, to sell on commission as side line high grade article that is needed and wanted by every power plant. AS-809, Power, Real Estate Trust Bldg., Phila., Pa.

PATENT ATTORNEY

C. L. Parker, patent attorney, formerly member Examining Corps, U. S. Patent Office, McGill Bldg., Washington, D. C. Inventors' handbook sent upon request.

BOOKS AND PERIODICALS

Steam Users' Guide

Engineers and firemen send 15 cents in stamps for pamphlet of Stromberg's steam users' guide. Stromberg's Pub. Co., 260 Whiton St., Jersey City, N. J., 4658a Pope Ave., St. Louis, Mo.

FOR SALE

Gas Producer Plant

Complete suction gas producer plant; consisting of one 250 hp. producer, one 80 hp. producer, also 50 hp. gas engine, generators, etc. Equipment can be seen in operation. J. Chein & Company, Harrison, N. J.

Production Checker

You can get a production checker at little cost; here is an opportunity to get a productograph to keep count and make curve chart record on one to twenty machines; first class condition, various spare parts included. Bargain price for quick sale. W. A. Hefner, c/o McGraw-Hill Co., New York.

Meter Bargain

Thomson swichoard type, 2-wire, 75-amp., 231-240 volts. Absolutely new; a chance to get a new meter at second-hand cost. W. A. Hefner, c/o McGraw-Hill Co., New York.

MISCELLANEOUS

Wanted Good Steam Specialty

or power plant device. Well-known company, having own factory, also sales organization covering entire country, would consider manufacture and sale of practical steam specialty or power plant device having substantial and unique value as money saver; also strong patent protection. M-861, Power.

U. S. GOVERNMENT

SEALED PROPOSALS, indorsed "Proposals for Power Plant Equipment, Bellevue, D. C., Specification No. 4497," will be received at the Bureau of Yards and Docks, Navy Department, Washington, D. C., UNTIL 11 O'CLOCK A. M., JANUARY 4, 1922, and then and there publicly opened, for installing four 150 horsepower, return tubular boilers with mechanical stokers, boiler feed and fire pumps, a motor driven air compressor and other equipment furnished by the Government and for furnishing and installing brick settings and superheaters for four 150-horsepower boilers, an I beam crane, two turbine driven, forced draft fans, steel smoke flue, feed water heater, heating system return tank condenser equipment including air condensate and circulating pumps, service water heater and circulating pumps, a traveling screen for the circulating water intake, structural steel supports and concrete foundations for the equipment and all necessary piping, valves, fittings and accessories at the Naval Experimental and Research Laboratory, Washington (Bellevue), D. C. Drawings and Specification No. 4497 may be obtained on application to the Bureau. Deposit of a check or postal money order for $20, payable to the Chief of the Bureau of Yards and Docks, is required as security for the safe return of the drawings and specification. C. W. PARKS, Chief of Bureau, October 31, 1921.

Additional Proposal Ad. on following page

U. S. GOVERNMENT

TREASURY DEPARTMENT, Supervising Architect's Office, Washington, D. C., December 19, 1921.—Separate sealed proposals will be opened in this office at 3 p.m., January 16, 1922, for an ice making and refrigerating plant for the U. S. Quarantine Station, New Orleans, La. Drawings and specifications may be obtained at this office in the discretion of the Supervising Architect. Jas. A. Wetmore, Acting Supervising Architect.

WANTED

Engine Generator Set

400 to 500 KILOWATTS

250-275 volts, D. C. direct connected only. Will not consider belted unit. Engine must be simple type, not compound. Prefer Unaflow or releasing Corliss. Would consider piston valve, but not slide valve. State manufacturer, shop numbers, age, condition, etc.

Madison Coal Corporation
Purchasing Department
902 S. Michigan Ave., Chicago, Ill.

ENGINE AND GENERATOR UNIT

1—450 to 500 kva. Direct Connected Engine and Generator Unit, 3 phase, 60 cycle, 2300 volts.
Give detailed description.
CHARLES L. PILLSBURY CO., *Engineers*
1200 2d Ave., South Minneapolis, Minn.

Exceptional Boilers

1—409 hp. B & W, 200 lb., N. Y.
1—100 hp. Crossdrum B & W, Mass. standard, 160 lb., N. Y.
2—300 hp. Altman-Taylor, 150 lb., N. Y.
1—200 hp. Stirling, 160 lb., N. J.
1—150 hp., Locomotive, 125 lb., N. J.
1—100 hp. Locomotive, 100 lb., N. J.
1—250 hp., Dryback, Scotch, 150 lb. Mass. standard.
1—80 hp. Dryback, Scotch, 130 lb.

Several Good H. R. T. Boilers

RUSSELL B. HOBSON,
West New Brighton, N. Y.

TRIPLEX PUMPS

(Brass Fitted)

3 x 4..... 21 G.P.M.
4 x 6..... 45 G.P.M.
4⅜ x 6 Ball Valve, 56 G.P.M.
5½ x 8.....108 G.P.M.
7 x 8.....180 G.P.M.
8 x 12.....260 G.P.M.

MARVIN BRIGGS, INC.,
167 Sixth St. Brooklyn, N. Y.

Would YOU buy a SECOND-HAND ELECTRIC MOTOR at ANY price?
If you KNEW it to be as good as new?
Wire us your inquiries.

GREGORY ELECTRIC CO. CHICAGO, ILLINOIS
Second-hand Electric Motors Bought, Sold and Exchanged.
In business since 1893.
16th and Lincoln Streets Chicago, Ill.

SEARCHLIGHT SERVICE SECURES SATISFACTORY SALES

2004

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at

Old Hickory

Machinery of all kinds, from the World's greatest Powder Plant, now offered to American Industry at prices far below present costs.

Just a few of the offerings:

44—823 hp. Stirling Boilers,
3—500 hp. Keeler Boilers.
27—350 hp. Corliss Engines.
1—3000 kw. Generator.
2—630 ft. Air Compressors.
2—2570 ft. Air Compressors.
10—14-in. 8,600 g.p.m. Pumps.
2—10-in. 3,750 g.p.m. Pumps.
4—14-in. 7,500 g.p.m. Pumps.
6—16-in. 8,500 g.p.m. Pumps.
6—14-in. 8,100 g.p.m. Pumps.
2—Underwriters Fire Pumps.
16—Hydraulic Pumps.
200—Boiler Feed Pumps.
200—Blowers.
2000—Steel Tanks, all sizes.
1—50 ft. 20 ton, R.R. Crane.
1—110-ft. Fixed Radius Crane.
1—2-6-0 Locomotive.
2000—Wood Tanks, all sizes.
35—Electric Locomotives.
5000—Narrow Gauge Cars.
500—Electric Motors.
11—Sulphuric Acid Plants.
5—Nitric Acid Plants.
Transmission Equipment.
Process Equipment.
Chemical Equipment.
Miscellaneous Equipment.
Etc. Etc. Etc.

Write for Special Bulletins as follows:

No. 7—Tanks, all kinds.
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No. 12—Industrial Cars.
No. 14—Chemical Equipment.
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Nashville Industrial Corp.
Jacksonville, Tenn.

PUMPS

From Old Hickory Powder Plant

Motor Driven Centrifugal

8—14-in. Worthington, Class B double suction, 8,500 G.P.M. at 152 feet head, at 1,170 R.P.M. direct connected to 300 hp. G. E., 3 phase, 60 cycle 2,200 volt motors.
4—14-in. Allis-Chalmers, Type S, 7,500 G.P.M. at 130 feet head, at 1,760 R.P.M. direct connected to 300 hp. General Electric, 3 phase, 60 cycle, 2,200 volt motor.
2—10-in. Allis-Chalmers, Type S, 3,750 G.P.M. at 130 feet head at 1,765 R.P.M. direct connected to 150 hp. Westinghouse, 3 phase, 60 cycle, 2,200 volt motors.

Steam Turbine Driven Centrifugal

6—16-in. Allis-Chalmers, Type S, 8,500 G.P.M. at 90 feet head, direct connected to Type L, 300 hp. 2,000 R.P.M., G. E. Curtis Steam Turbine.
6—14-in. Allis-Chalmers, Type S, 6,500 G.P.M. at 150 feet head, 8,100 G.P.M. at 90 feet head, direct connected to 300 hp., 2,000 R.P.M., G. E. Curtis Steam Turbine.

Steam Actuated Hydraulic

5—14-in. and 20 x 7½ x 18 Worthington Compound Duplex outside packed plunger pot valve, 400-g.p.m. at 300-lb. pressure.
8—25 and 38 x 4½ x 24 Worthington Tandem Compound Duplex, outside packed 3,600 lb. pressure, 150-g.p.m. at 20-r.p.m.
1—20 x 12 x 16 Worthington Duplex Underwriters Fire Pump. 1,500-g.p.m., 100-lb. pressure.
200—New and used Simplex and Duplex, steam driven Worthington Pumps, 4½ x 3¾ x 4. 5½ x 4¾ x 5, 6 x 4 x 6, 7½ x 4½ x 10, 6 x 2½ x 6
100—New and used Belted, 2½ 3, 4, 5 and 6-in. Centrifugal Pumps.

Nashville Industrial Corp.
Jacksonville, Tenn.

STACKS

Three self-supporting steel stacks 20 ft. diameter at base tapering to 16 ft. diameter at top; height 250 ft. Two are new, other used three months.

Coal and Ash Handling Machinery

Complete coal and ash handling equipment for 17,000 hp. Boiler Plant. For full particulars address

Roy Brenholts, Trustee,
1015 Outlook Building, Columbus, Ohio

FOR SALE

BOILERS

Battery of two new horizontal return tubular 72 in. x 18 ft. A.S.M.E. specifications for 150-lb. working pressure and complete with fronts, grates, suspension and accessories. Cost $8700, bargain for cash $4500.

Apply Box "P," Passaic, N. J.

Four Corliss Engines

For Quick Sale at Right Prices.

18 x 36, 350 hp.
2—Allis-Chalmers, R.H.
2—Nordberg; 1 R.H., 1 L.H.
Write or Wire.
WILSON-HOCK COMPANY
City Point, Va.

625 KVA. ENG. SET

G.E. Gen. 480-240 V., 60 Cy., 3 Ph., Allis Heavy Duty Eng., 22 in. x 44 in. x 42 in.
Also Turbo Set (Same. Specs.)
Exceptional Bargains

ROSS POWER EQUIP. CO.
Indianapolis, Ind.

BOILERS

Ten Kewanee, 150 hp., Horizontal Tubular Boilers for sale. Built 1917-1918. Hartford certificate. Serviceable for power or heating.

FS-865, Power
10th Ave. at 36th St., New York City

Surety Motors

Performance Guarantee Backed by Surety Bond

BONDED

Under Bonds for Good Behavior

The license label of the Surety Motor Bonding Company on a renewed motor means that the motor is expected to make good.

Every renewed motor sold by a licensee carries with it a guarantee that it has been put in such working condition that it will operate like a standard motor when taken from the manufacturer brand new.

The company selling the motor issues to the purchaser a Certificate of performance, which may be exchanged for a Surety Bond when the purchase price is paid, which guarantees the licensee's guarantee. The motor is under bonds for good behavior.

Write the following licensees for full information and stock lists of rebuilt equipment available for immediate delivery:

Duquesne Elec. & Mfg. Co., Frankstown & Hamilton Aves., Pittsburgh, Pa.
Elliott Electric Co.....813 Superior Ave., N. W., Cleveland, O.
Guaranteed Motor Co.....2814 Wentworth Ave., Chicago, Ill.
Miller-Seldon Electric Co.....1259 Park Pl., W., Detroit, Mich.
Willey-Wray Electric Co.....118 West Third St., Cincinnati, O.

Surety Motor Bonding Company

SURETY RENEWED MOTORS BONDED — SURETY MOTORS (BONDED)

133 W. Washington St., Chicago

Surety Motors

Performance Guarantee Backed by Surety Bond

BONDED

Engine Type Generator

1—200- kw., 275 volt, 195 r.p.m., compound wound, Type CCD, renewed Crocker-Wheeler D.C. generator, direct connected to an 18¾ by 21 inch right hand Buckeye engine.

1—2 Panel Vermont marble switchboard with circuit breaker, ammeter, field rheostat and main generator switch.

Engine complete with throttle valve, gravity feed oiling system, cylinder lubricator and drain valves.

Approximate floor space of foundation 17 ft. by 19 ft.

Complete stock of new General Electric motors and renewed motors for immediate delivery. Write for full information regarding renewed bonded motors.

The Elliott Electric Company
OF CLEVELAND

Licensee—Surety Motor Bonding Co.

RENEWED MOTORS BONDED — SURETY MOTORS (BONDED)

MILLER-SELDON ELECTRIC COMPANY

MOTORS SUPPLIES ELECTRICAL CONSTRUCTION

Authorized General Electric Motor Dealers

MOTORS AND GENERATORS

Rewound and repaired. Coils of every description. Our shops are equipped with superior facilities, manned by expert repairmen. Prompt and efficient attention to repairs and replacements on any type or size of equipment.

RENEWED MOTORS BONDED — SURETY MOTORS (BONDED)

LICENSEES:
Surety Motor Bonding Company

General Offices:
1259 Park Place, Detroit, Mich.

Shops and Warehouse:
2600 Isabella St., Detroit, Mich.
M. C. R. R. private siding.

Send for Our Stock List of New and Used Motors.

SURETY BONDED EQUIPMENT

Direct Current Motors
230 Volts

No.	*Hp.*	*Rpm.*	*Wdg.*	*Type*	*Make*
1	2	1100	Sh.	CM	Cr.-Wh.
1	4	535/1070	Sh.	CM	Cr.-Wh.
1	5	1650	Sh.	CE	Gen. Elec.
1	5	1850	Sh.	CM	Cr.-Wh.
1	6	750/1500	Sh.	SK	Westghse.
1	7½	825	Sh.	CVC	Gen. Elec.
1	7½	1150	Sh.	SK	Westghse.
1	10	1125	Sh.	S	Westghse.
1	15	750	Sh.	MP	Fbks.-Morse
1	15	750	Sh.	MP	Gen. Elec.
1	20	650	Cp.	S	Westghse.
1	20	250/1000	Sh.	SA	Westghse.
1	40	750	Sh.	RC34	West. Elec.
1	40	950	Cp.	M	Westghse.
1	45	600/1200	Sh.	MP	Northern
1	45	800	Sh.	MP	Imperial
1	50	525	Cp.	S	Westghse.
1	80	1000	Cp.	A50	Milwaukee
1	90	1000	Cp.	A50	Milwaukee

Direct Current Engine Generator Sets

1—17-kw., 125-volt, D.C., cp.wd., 300-r.p.m. Northern Generator, direct connected and mounted on common bed plate to Russel Steam Engine, 100 lb. steam pressure, complete with all accessories.

1—75-kw., 250-volt, 275-r.p.m., cp.wd. Allis-Chalmers, D.C. Generator, direct connected to Chandler & Taylor horizontal single cylinder, side crank slide valve steam engine, 14 x 14, 100 lb. steam pressure, complete with all accessories, including switchboard.

1—150-kw., 250/125 C., 3-wire Engine Generator Set, consisting of 2—75-kw., 125-volt, D.C. Burke Generators, mounted on common shaft and coupled to 1—Fleming Harrisburg, single cylinder, 2-valve steam engine, to operate 125-lb. steam pressure, complete with all accessories, including switchboard.

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No.	*H.P.*	*R.P.M.*	*Type*	*Make*
3	40	1200	IK	Gen. Elec.
4	40	1200	CS	Westingh.
1	50	1200	B	Fair.-Mor.
1	75	720	IM-Sl.Rg.	Gen. Elec.
1	100	900	CS-Sq.Cg.	Westingh.
1	135	900	ATB Syn.	Gen. Elec.
1	180	900	Sq. Cage	Burke

3 Ph., 60 Cy., 240/480 V. Alternators

No.	*Kva.*	*R.P.M.*	*Type*	*Make*
1	90	900	AB	Fair-Mor.
1	100	900	ATB	Gen. Elec.

250 V. Direct Current Generators

No.	*Kw.*	*R.P.M.*	*Volts*	*Type*	*Make*
1	150	575	250		Ridgeway
1	50	950	250	H	Bullock

1—30 Kw., 125 V. Ideal Generator direct connected to 3 Ph., 60 Cy., 220 V. Ideal motor.

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M. 1—10,000 K.W. General Electric Condensing Turbo Unit 25 Cyc., 3 Ph., 6600 Volt. Complete with Surface Condenser and all Auxiliaries.

N. 1—1500 K.W. General Electric Condensing Turbo Unit 25 Cyc., 3 Ph., 11,000 Volts.

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625	Wghse.	Parsons Turbine
600	G. E.	Rice-Sargeant-Corliss
500	Wghse.	Parsons Turbine
500	Wghse.	Hamilton Corliss
475	G. E.	Skinner Uniflow
375	G. E.	Curtis Turbine
360	G. E.	Harris Corliss
300	Allis-Chal.	Skinner, 20 x 20
250	Allis-Chal.	Hamilton non-releasing
200	Wghse.	Ridgway
150	Wghse.	Rice-Sargeant-Corliss
150	Allis-Chal.	Ideal Tandem
125	G. E.	Harrisburg
120	G. E.	Hamilton, 12 x 24
100	G. E.	Harrisburg
75	G. E.	Harrisburg
50	G. E.	Erie Ball

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Kw.	*Generator*	*Engine*
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200	Wghse.	Erie Ball
100	Wghse.	Erie Ball
75	G. E.	Skinner
75	Allis-Chal.	Erie Ball
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50	Wghse., 3-wire	Ames
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200	G. E.	Fleming, 4-valve
100	Wghse.	Skinner
75	G. E.	Harrisburg
60	G. E.	Harrisburg
50	G. E.	Harrisburg
50	Wghse.	Skinner
30	G. E.	G. E. Marine
30	G. E.	Erie Ball
25	Wghse.	Erie Ball
20	G. E.	Harrisburg
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ELECTRICAL REVIEW AND INDUSTRIAL ENGINEER will be devoted to the problems of electrical and mechanical operation and maintenance in industrial plants, a field which the *Electrical World* will continue to cover as in the past, but from a technical engineering standpoint. With the extended use of electric service in industrial production processes, there has grown a demand for specific and practical information on the operation of electrical systems by those who take up the work where the consulting, designing and installation engineers leave off. To these practical men a service not heretofore available will be provided.

ELECTRICAL WORLD, as in the past, will be devoted to the problems of executives and electrical engineers responsible for the administration of policies, for engineering developments, and for practices in all branches of the electrical industry. Its editorial scope, except for broadening, remains unchanged, and embraces (1) the fundamentals of electrical engineering *as a profession*, (2) production, distribution and application of electrical energy *as a service*, and (3) the broad problems of production, distribution and application of electrical equipment and merchandise *as a business*.

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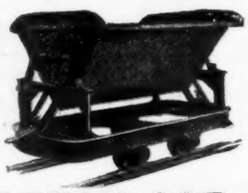

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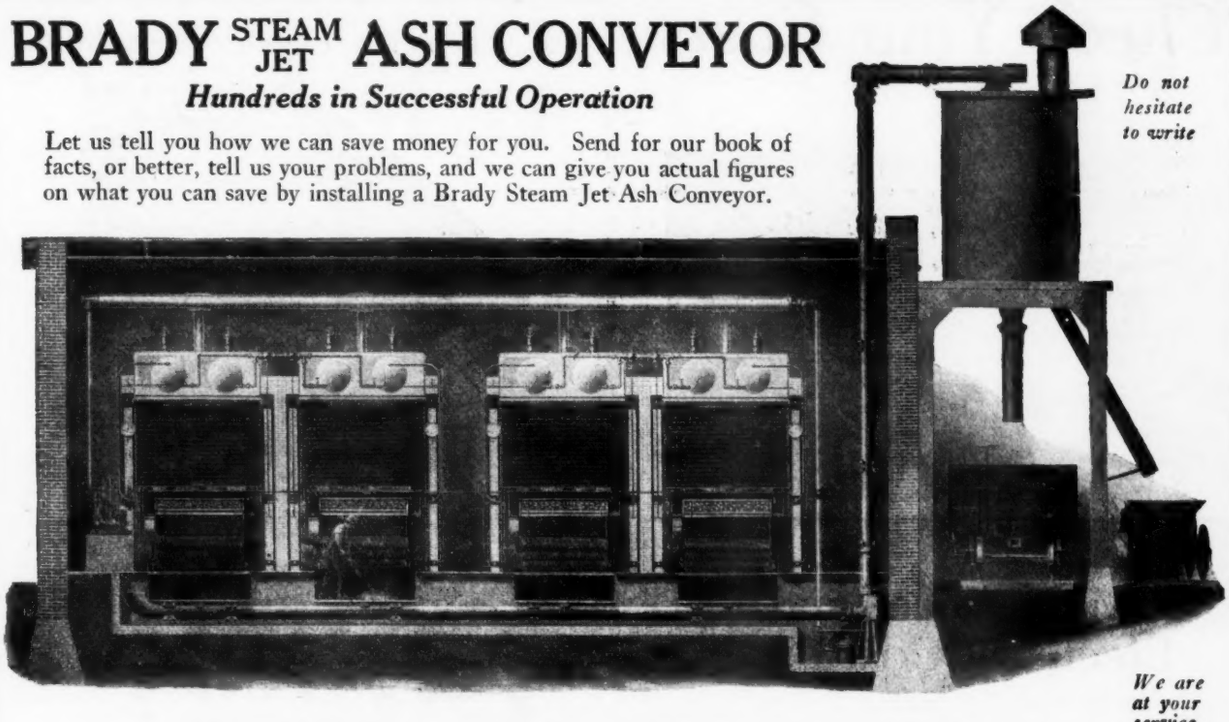

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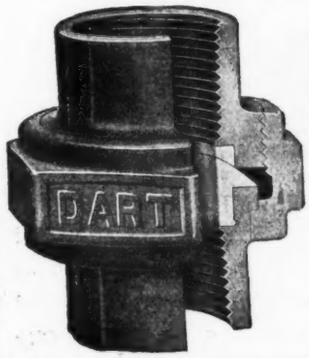

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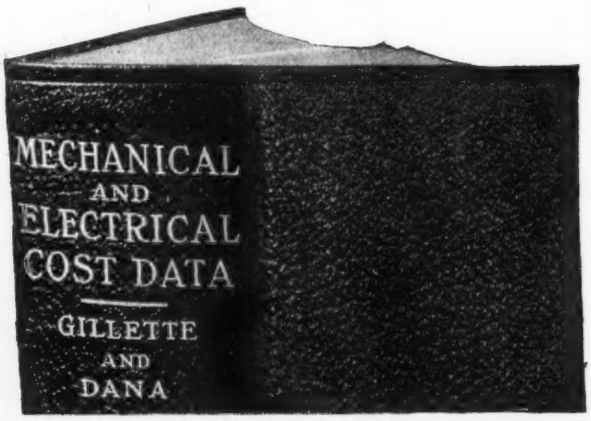

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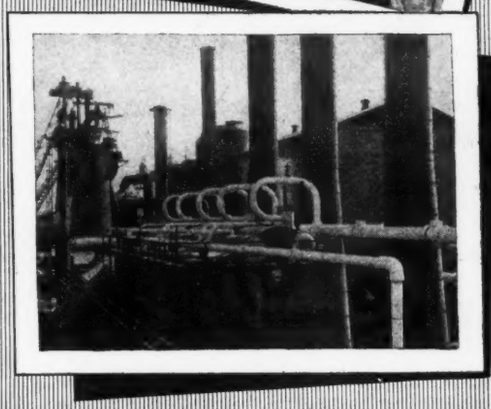

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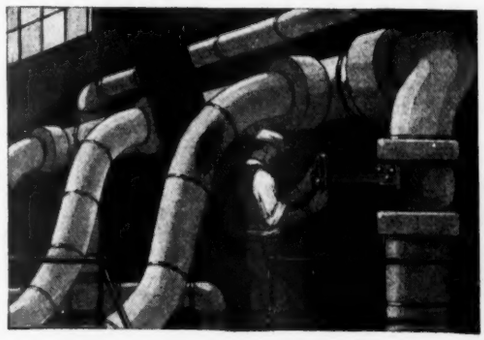

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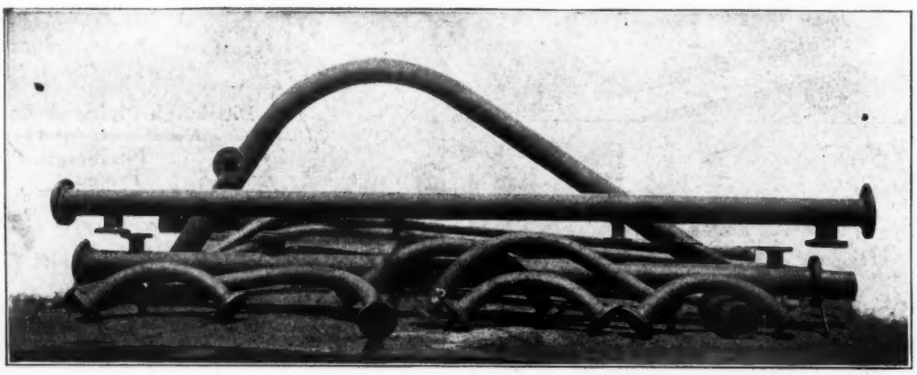

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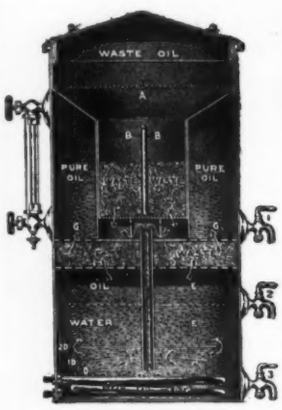

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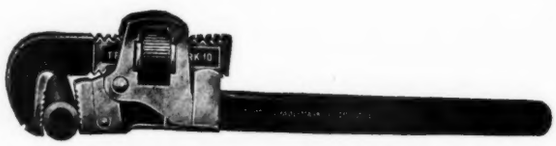

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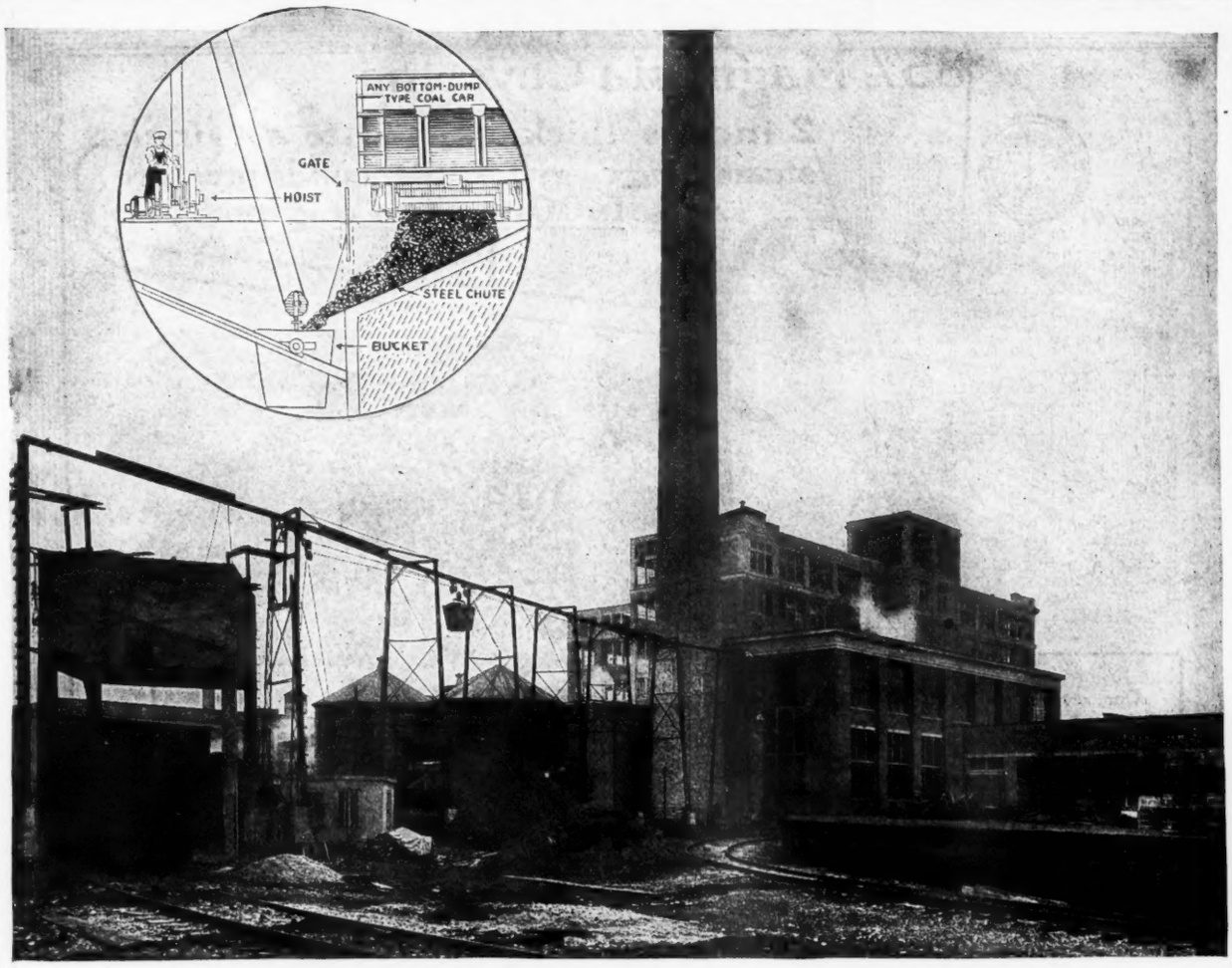

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One System for Handling Both Coal and Ashes

THIS prominent Indianapolis manufacturing plant pictured above unloads coal from cars to storage or direct to bunkers in boiler room as desired. Before installing their Godfrey Conveyor, it cost 60 cents per ton to carry coal from cars to their boiler room by the old fashioned hand shoveling—wheelbarrow method. Their superintendent states it now costs them only 6 cents per ton. ARE YOUR HANDLING COSTS AS LOW? The same system is used to carry ashes from pits in boiler room to an outside receiving tank or dump pile. All of this "handling" is accomplished by the service of only ONE MAN and a "Godfrey."

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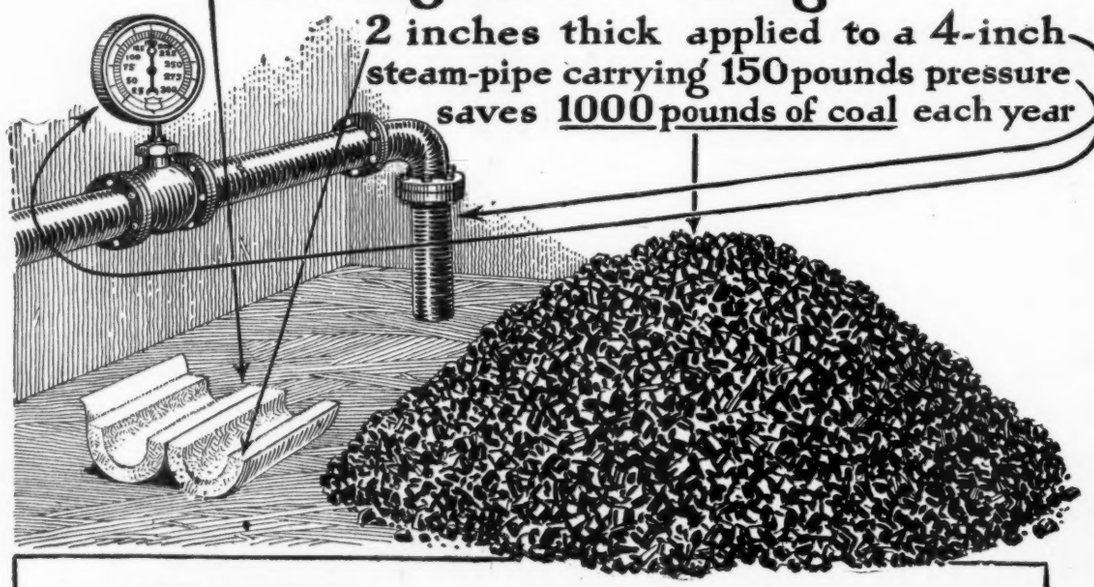
Every Foot of 85% Magnesia Covering

2 inches thick applied to a 4-inch steam-pipe carrying 150 pounds pressure saves 1000 pounds of coal each year



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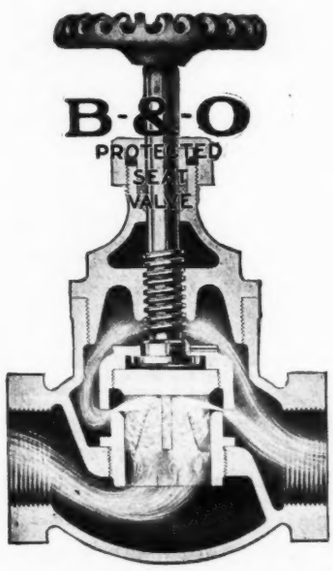

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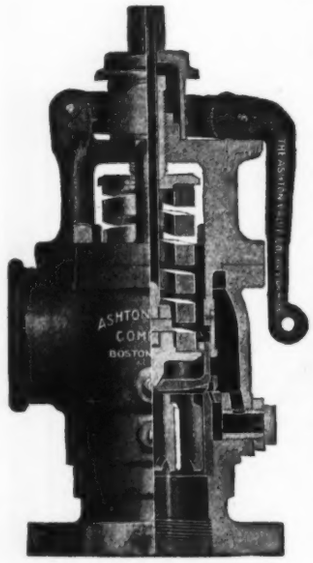

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is made of cast steel body, valve part and seat bushing of solid nickel. Has outside pop regulator, knife-edge pop-lip and compound lifting lever easily raised by hand, the set pressure adjustment being locked to prevent tampering.

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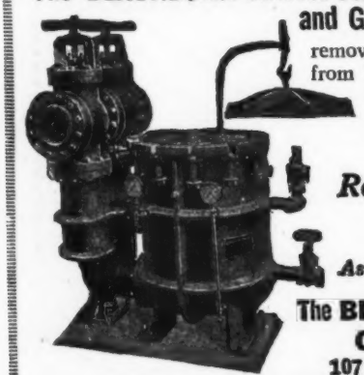

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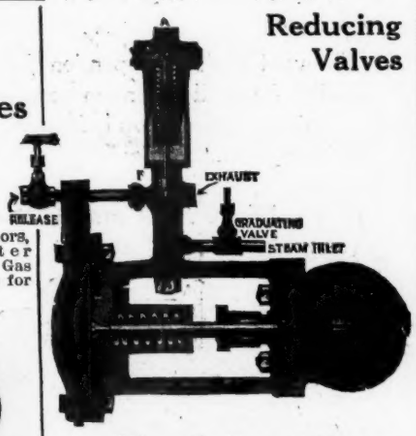

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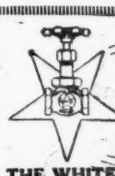

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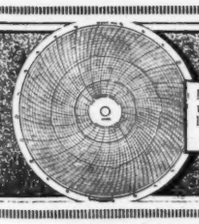

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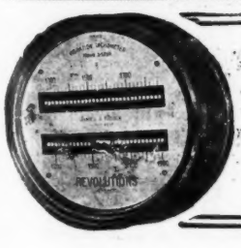

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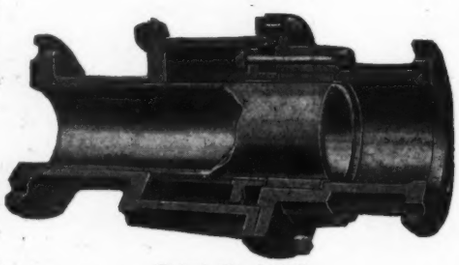

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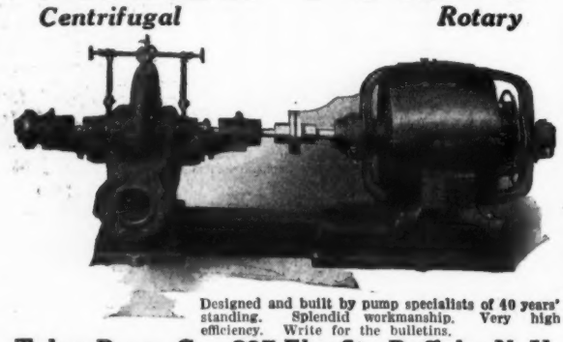

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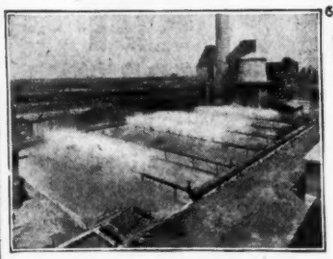

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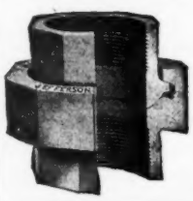

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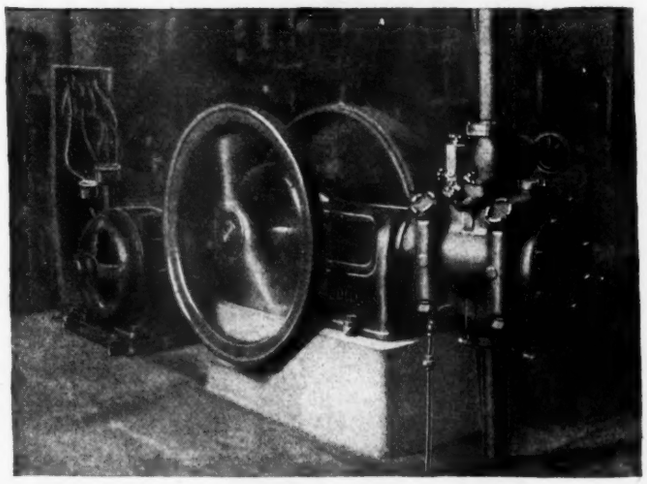

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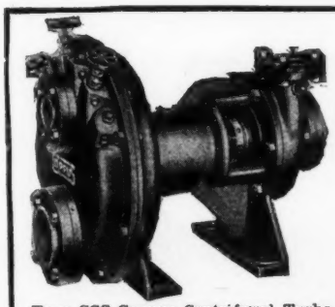

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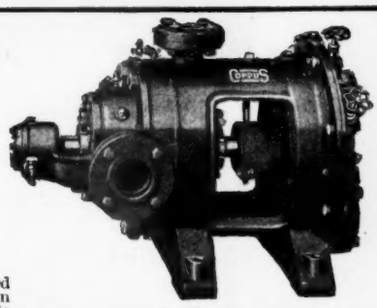

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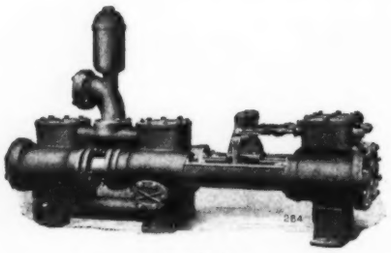

Fig. 6284

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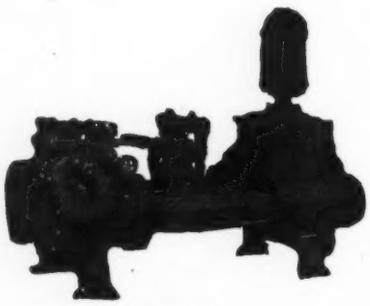

Fig. 6439

Patterns for Semi-Corliss, Piston valve and slide valve steam ends and water ends of Packed piston, outside center packed plunger and pressure patterns.

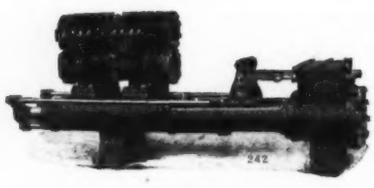

Fig. 6242

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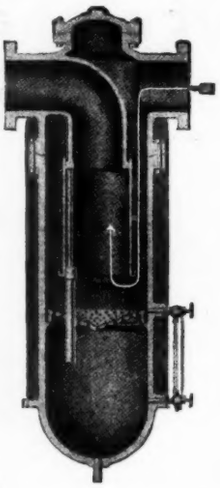

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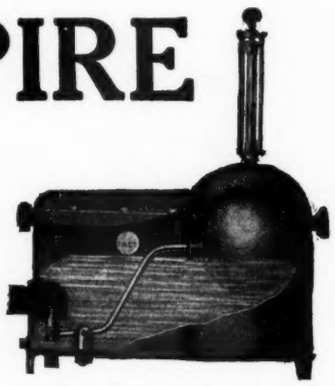

A "Low Pressure" trap, for use on less than 20 lbs. pressure. Inverted valve seat prevents sediment lodging on seat. Blowoff plug is directly under valve seat. Seamless electro-plated copper float, tested to 150 lbs. Long automatic air valve, placed at highest point. Two inlets, one on either side; one end outlet, for convenience in piping. Write for special folder on Empire Trap.

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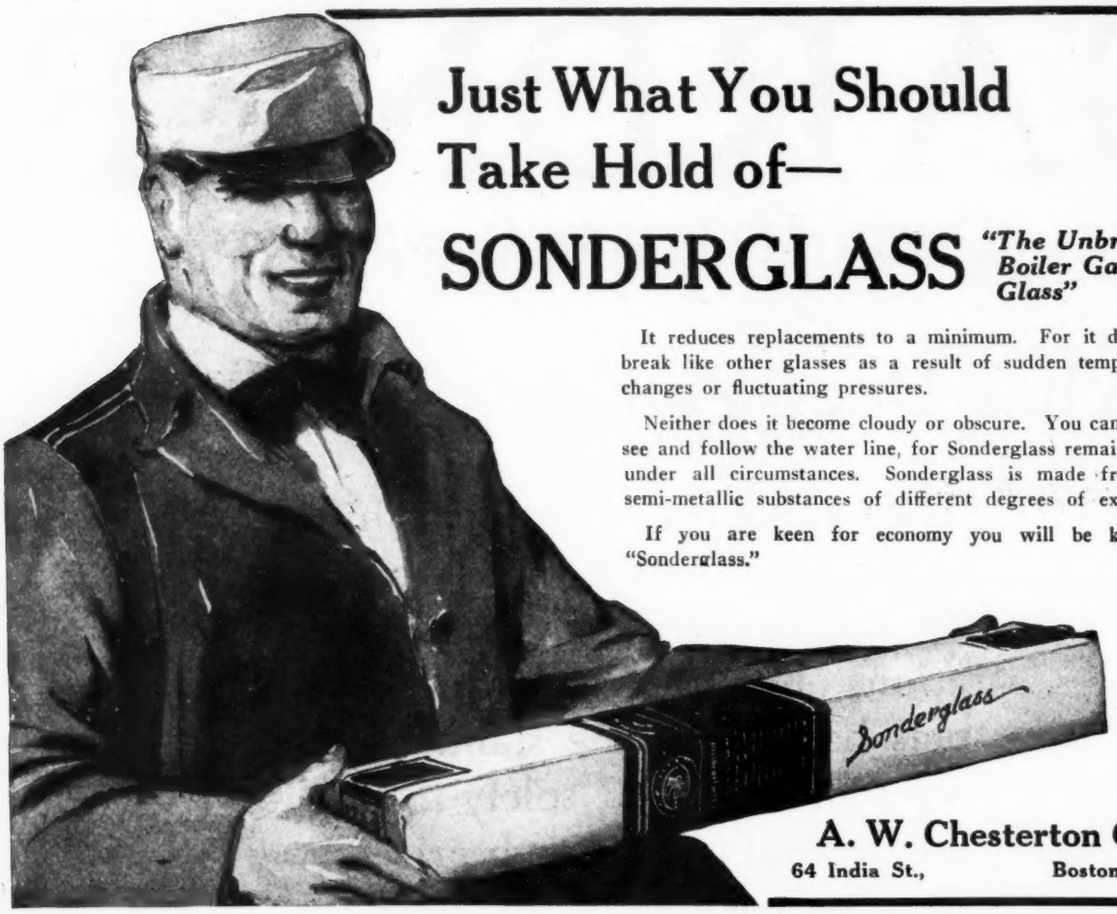

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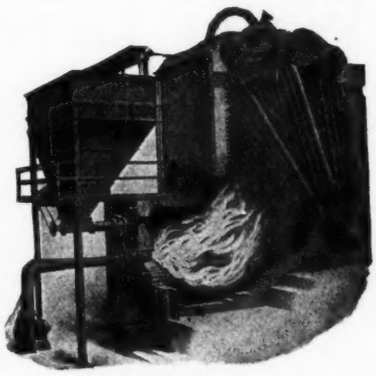
For High Overloads and Maximum Combustion Economy



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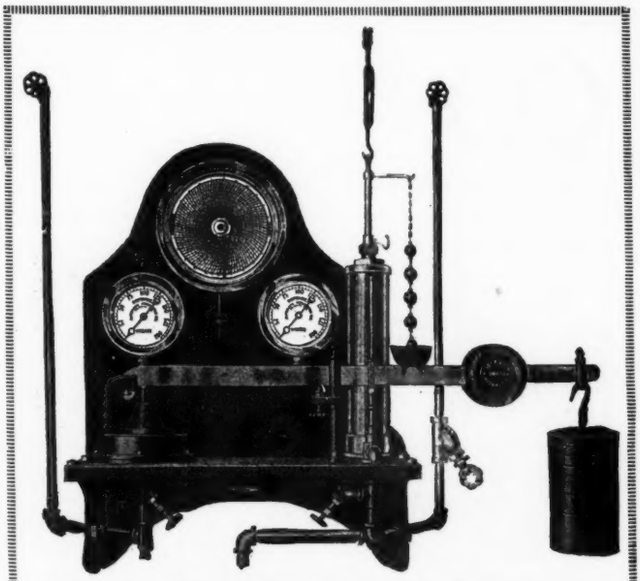

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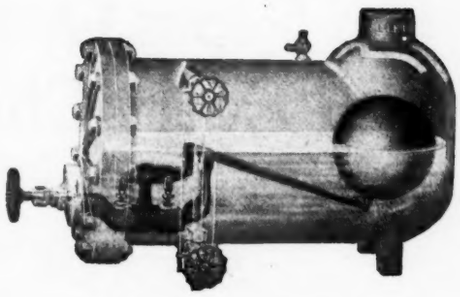

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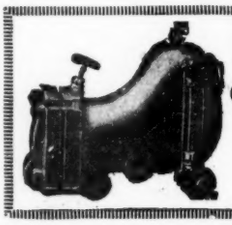

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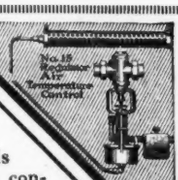

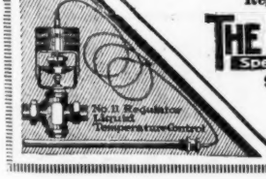

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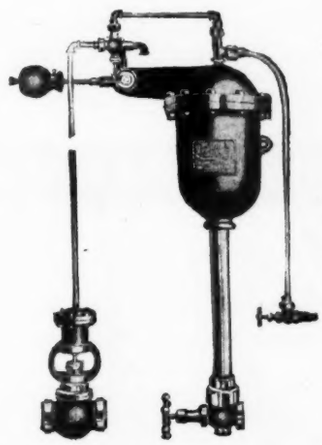

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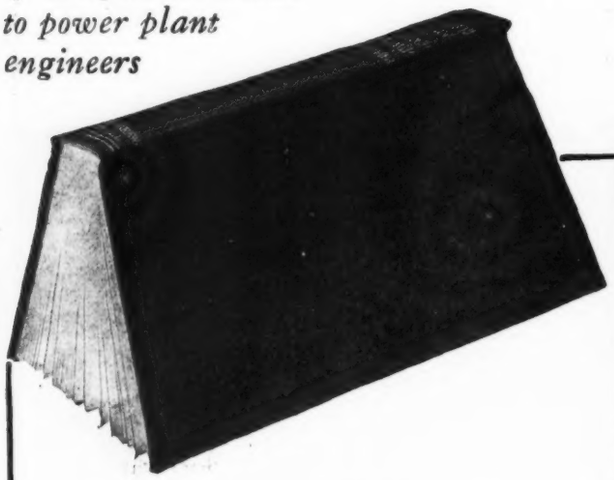

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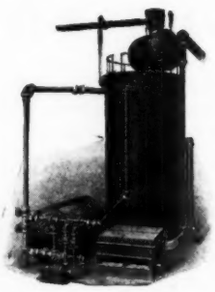

Supplies softened water that can form *no* scale!

The endless chain of cleaning costs and fuel loss

—*Have you ever stopped to figure it out?*

THERE is scale in your boilers—that is, unless you are feeding hot rain water or its equivalent, softened water from the International Hot-Flow Water Softener. You attack this scale occasionally with turbines, cleaners, chemical compounds and flint-lock methods. You realize, of course, that this way of fighting scale is about as effective as shoveling snow from your sidewalk during a snow storm—an endless chain of increasing and diminishing scale cleaning costs repeated over and over—and fuel loss *always*.

Take up the links in this endless chain one at a time. We will send you some leading questions that will enable you to do just this. You will find that you are paying for softened water without getting it!

International Hot-Flow Water Softeners combine the feed water heater and the water softener plant. By heating the water, the chemical reaction is accelerated. This means greater capacity in smaller space.

Chemical feed is automatic.

The "hot flow" is so arranged that changing temperature does not affect "holding time."

Let us supply you with some vital facts that every power plant operator should have.

INTERNATIONAL FILTER CO.
First National Bank Bldg., Chicago
Woolworth Bldg., New York

INTERNATIONAL WATER SOFTENERS

THE BABCOCK & WILCOX COMPANY

85 LIBERTY STREET, NEW YORK

Builders since 1868 of Water Tube Boilers of continuing reliability

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CLEVELAND, Guardian Building
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ATLANTA, Candler Building
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WORKS

Bayonne, N. J.
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Makers of Steam Superheaters since 1898 and of Chain Grate Stokers since 1893

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SEATTLE, L. C. Smith Building
HAVANA, CUBA, Calle de Aguiar 104
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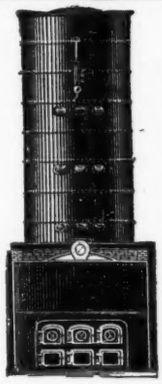

Steel Cased Setting Increases Efficiency.

Wickes Vertical Water Tube Boiler

Have you seen the STEEL CASED SETTING for enclosing this boiler?
Air infiltration losses are overcome.
The highest possible thermal efficiency results.

Ask for bulletin—Magnitude and Prevention of Air Infiltration Losses—sent free

THE WICKES BOILER CO., SAGINAW, MICH.

SALES OFFICES:

New York City, 1716 West St. Bldg.
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Boston, 201 Devonshire St.
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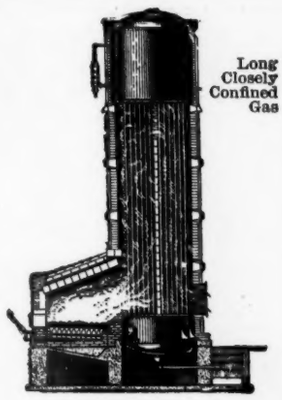


Long Closely Confined Gas

Badenhausen

Boilers
Superhearets
Preheaters

Phillips Badenhausen

1425 Chestnut Street, Philadelphia, Pa.
90 West Street, New York City, N. Y.

"Sectional Water Tube Boiler Specialists for Over Fifty Years"

ROOT

WATER TUBE BOILERS
SPIRAL RIVETED PIPE

Abendroth & Root Manufacturing Co.

Works: Newburgh, N. Y.
New York Office: Woolworth Building, 233 Broadway.

UNION
Water Tube Boilers

Quick steamers with high overload capacity. Easily cleaned. Very flexible in construction. The self-contained feed water purifier keeps the tubes remarkably free from scale.

Investigate! Write.

UNION IRON WORKS
Erie, Pa.

American

Pop Safety and Relief Valves; Gauges; Gauge Testers; Steam Engine Indicators; Steam Traps; Feed Water Filter; Whistles; Counters and Clocks are backed by 70 years' experience. Write for Catalog No. 70.

American Steam Gauge & Valve Mfg. Co.
Boston, Mass.
Branches in large cities

VENTURI METERS

Measure hot and cold water, sewage, brine, chemical solutions, oil, gas, air and steam.

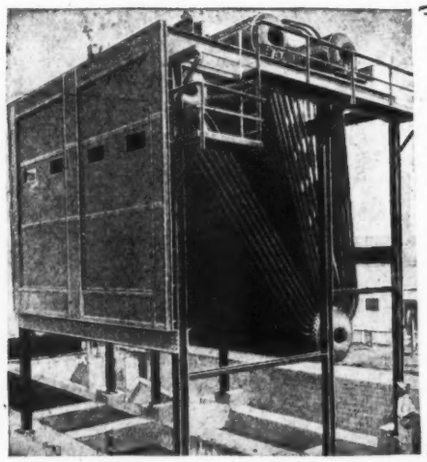
Bulletin on request

BUILDERS IRON FOUNDRY, Providence, R. I.

Are You Regulating Your Boilers The WRONG Way?

If your Stokers, Fans, or Dampers are being operated on the "open and shut" principle they are being operated the WRONG WAY, absolutely.
Over 9000 engineers have already agreed on this, and now accept the Hagan "Control from Flow" System as the correct principle. *Booklet No 17 tells the story. Write for it.*

The Hagan Corporation *Combustion Engineers* **Pittsburgh, Pa.**



This picture shows a 1058-H.P. unit at Andrews Steel Co., Newport, Ky.

Connelly Water Tube Boilers

(Patented)

are of the 4-drum type, have 100 per cent. tube area in the path of the circulation, and deliver steam slightly superheated. Simple in design, have no flat surfaces, no stay-bolts, and free from hundreds of joints (no handholes). Easily accessible for cleaning internally and externally. Can be built in units up to about 4000 hp.

Write for copy of our new Catalog. (Desk 4)

The D. Connelly Boiler Co., Cleveland, Ohio

Founded in 1875 by Daniel Connelly

HEINE LARGE UNIT BOILERS

Water Tube Boilers
Longitudinal Drum Cross Drum
Waste-Heat Boilers

Heine Boilers Conform to A S M E Boiler Code

Heine Boiler Company
St. Louis, U.S.A.

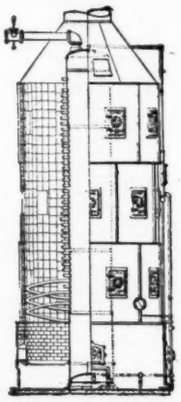
BOILERS

that make steam at low cost

The high fire chamber of MORRIN-CLIMAX Vertical Tube Boilers effects a more perfect combustion of fuel, and the loop tubes afford best opportunity for heat absorption.

Write for further details.

Morrin-Climax Boiler Co.
Jersey City, N. J.



Coatesville Boiler Works

Manufacturers of
Boilers, Steel Tanks and Special Steel Plate Construction

WORKS: Coatesville, Pa. Sales Offices: 30 Church St., New York, N. Y. Morris Building, Philadelphia, Pa. 141 Milk St., Boston, Mass.

LADD WATER TUBE BOILERS

The George T. Ladd Co.
First National Bank Building. Pittsburgh, Pa. Chicago Offices 528 McCormick Bldg.

Page Water-Tube Boilers

Two boilers in one; criss-cross tubes give double capacity. Entirely enclosed in airtight steel casing; no brick settings. Oscillating soot blower standard equipment. Also manufacturers of waste heat boilers. For complete catalog write the Page Boiler Co., 817 Larrabee St., Chicago, Illinois.

KEELER BOILERS

EST. 1864

Water Tube, Return Tubular and Cross Drum Types.

E. Keeler Co. Williamsport, Pa.

BRANCHES: NEW YORK-PHILADELPHIA-BOSTON-BUFFALO-CHICAGO

Less Corrosion and Pitting

PARKESBURG CHARCOAL IRON BOILER TUBES

Write for Bulletin
PARKESBURG IRON CO.
Beale Bldg., Parkesburg, Pa.

THE SIMPLEST STOKER IN THE WORLD

COKAL HAND STOKERS

Hundreds of satisfied users report saving of fuel and increased boiler capacity.

Write for Catalog

COKAL STOKER CORPORATION
1027 No. Clark St., Chicago

BIGELOW-HORNSBY BOILERS

Unexcelled in steaming economy and maintenance. Straight tubes—capacities to 3,000 hp. Write for catalog B. H.-20.

The Bigelow Co.
68 River St., New Haven, Ct.
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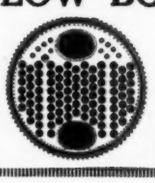
UNIFLOW BOILER

High Efficiency
Stacks, Tanks, General Plate Work
We Design, Manufacture and Erect.



Patented
Lebanon Boiler Works
J. K. Petty & Co., Proprietors
Est. 1870
Main Office: 2 South 15th St., Philadelphia
Works Lebanon, Pa.

LINCOLN said:

"I will study and get ready and sometime my chance will come."

So with

Springfield Boilers

We studied and got ready and our chance came.

While studying, we "made haste slowly"—installed our boilers in different parts of the country—under differing conditions—with different fuels—to satisfy ourselves that our belief in our boiler was well founded.

The fact that we have been compelled to devote our entire facilities to this one boiler—discontinuing all other articles which we formerly manufactured—is evidence that we did satisfy OURSELVES.

BUT—did we satisfy those who installed SPRINGFIELD BOILERS?

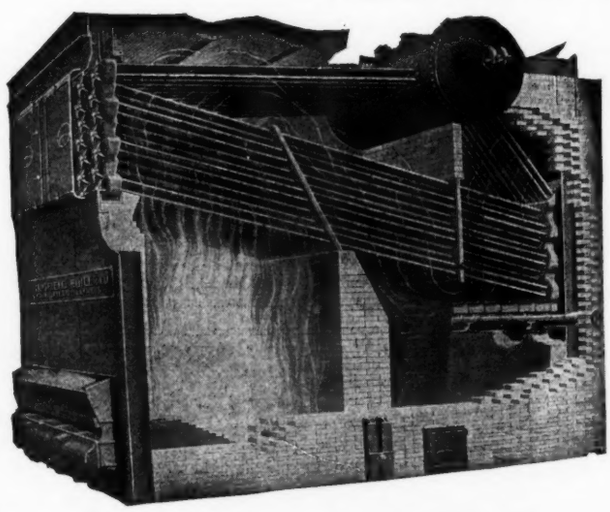
The answer—logical, we believe—is that many large power users, those who keep careful record of boiler performance and who installed our boilers are favoring us with their REPEAT ORDERS.

The largest power users and leading engineers are installing them. As an instance, we are at this time installing 23,000 horse power of SPRINGFIELD Boilers in what will be, upon completion, the largest central power station in the WORLD. They did not buy without satisfying themselves that the SPRINGFIELD Boiler was in construction and operation what we claimed for it.

Our Chance Did Come

Your chance to investigate is here. Don't neglect it.
Our Catalog for the asking.

SPRINGFIELD BOILER CO.
SPRINGFIELD, ILLINOIS



Sectional—All Steel
NO staybolts—
NO bent tubes
Sizes to 3000 hp.
Pressures to 500 lbs.

OFFICES:—

Chicago	Richmond	Kansas City
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66 Years of Engineering Experience

Since 1855 we have been manufacturing a complete line of high grade boilers, engines, feed water heaters, stacks and tanks. We have standardized where possible and can offer efficient equipment to power plants at an attractive figure.

Let Us Supply You With

BOILERS **ENGINES**

Power	Steel Casings	Fan	Vertical
Heating	Steel Stacks	Paper Mill	Throttling
Oil Country	Boiler Castings	Lighting	Oil Well Drilling

Open and Closed Feed Water Heaters—Pressure and Storage Tanks

Write us for Bulletins

The
BROWNELL COMPANY
DAYTON, OHIO·U·S·A·
Established 1855

BOILER TUBES

FOR ALL TYPES OF BOILERS

(A. S. M. E. SPECIFICATIONS)

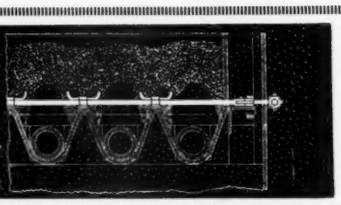
Curved tubes for every type of vertical water tube boiler.
Swaged tubes and copper ferrules.

BOILER TUBE CO. OF AMERICA

Main Office, 1228 Park Bldg., Pittsburgh, Pa. | 902 1st Nat. Bank Bldg. Birmingham, Alabama | Chicago: 809 Peoples Gas Bldg. (Works—Carnegie, Pa.) | 1814 Woolworth Bldg. New York

An eighth inch coating of
EVERTITE
will make any boiler setting air and gas tight, as well as moisture proof for years. Easily applied with a trowel. Write for full information.
Excello Mfg. Co., Cleveland, Ohio

THE NEGUS-TIFFANY COAL AGITATOR
WET COAL DIFFICULTIES DEFINITELY CURED
W. E. ELLIS COMPANY
HAVERHILL, MASS. U.S.A.



MODEL AUTOMATIC SMOKELESS FURNACE

Burns the cheapest coal at high efficiency.

Model—Chicago Chain Grate | Model—Acme Engine

THE AUTOMATIC FURNACE COMPANY
Dayton, Ohio

RUST CHIMNEYS
RADIAL BRICK AND REINFORCED CONCRETE
REFRACTORY BRICKWORK
The RUST ENGINEERING CO.
ENGINEERS AND CONTRACTORS
PITTSBURGH WASHINGTON BIRMINGHAM

Turner Baffle Walls
Produced exclusively by The Engineer Company

Sales Offices in the Larger Cities

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Balanced Draft
Produced exclusively by The Engineer Company

Your Boiler Settings Last Longer
when laid up with
HYTEMPITE
Ask for literature on laying up brick and patching
Quigley Furnace Specialties Co., 26 Cortlandt St., New York

R-K DRAFT REGULATORS
are used by leading combustion engineering concerns.
Write for Bulletin A-3.
Ruggles-Klingemann Mfg. Co.
15 Foster Court North Salem, Mass.

Show the Boss Some Savings—He Sorely Needs Them

For years the Boss has been working under high pressure. First it was war demands. Then came urgent home demands. **"Production! Turn out the goods—figure costs later."** That's the way the Boss talked—then.

He's talking differently now. What's worrying the Boss today is not production but **"cost"** of production. Competition is fierce—only by the strictest economy can he run and break even.

Every employee can help—by greater economy and efficiency—the engineer more than anyone.

How? By producing more power while burning less fuel!

The cuts shown illustrate how the free passage of heat to the water is **obstructed** by scale-coated boiler tubes and how the full passage is **insured** by thoroughly cleaned tubes.

The record tabulated below was given to us without solicitation.

		Savings per Year	Costs per Year
Cost of Roto Type A.D. Cleaner bought 4 years ago for $110.00—cleaned over 50 miles of 4-inch tubes. (No cost for motor repairs)	....	....	$27.50
Cutter head, cutters, bolts, etc	....	....	26.05
Coal savings— Average daily fuel consumed—12 tons at $5.50 per ton. Conservatively figured at 3 per cent—yearly saving 130 tons Coal savings arising from more frequent cleaning. With the Roto the tubes are now cleaned four times a year instead of twice as with the old machine. Also more thorough cleaning due to Roto snug-fitting motor.	....	$712.80	.....
Labor savings— With the old cleaner it required 80 days of labor at $5.00 per day to clean all of the tubes twice a year	$400.00	....	.....
With the Roto it required 32 days of labor at $5.00 per day to clean all of the tubes four times a year	160.00	....	.....
Making a total of 48 labor days saved at $5.00 per day		240.00	
Tube savings— When using the old cleaner an average of 25 tube replacements were made per year at $10.00 per tube	250.00	.....	.....
Since the Roto was adopted no replacements were necessary	None	250.00	.....
		$1,202.80	$53.55
Average yearly cost for Roto		53.55	
Average yearly saving		**$1,149.25**	

A Clean Boiler Tube through which heat passes freely to the water

A Scale-coated Tube through which heat struggles to reach the water

$712.80—over 13 times the yearly cost of cleaner and parts saved in coal.

$240.00—over 4 times the yearly cost of cleaner and parts saved in labor.

$250.00—over 4 times the yearly cost of cleaner and parts saved in failed tubes.

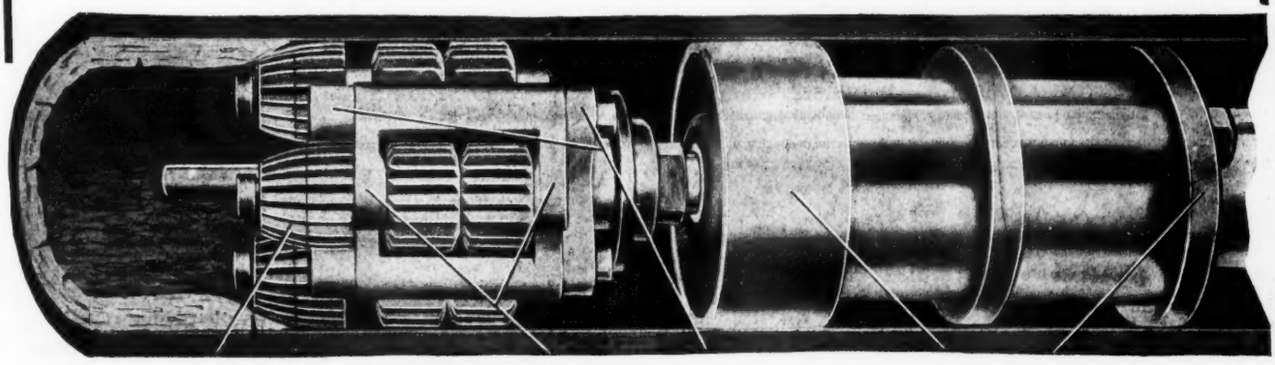
Similar Savings will commence as soon as you start using the ROTO Cleaners.

Roto is Thorough, Fast and Safe. Gets all the scale, reduces the time of cleaning and cannot damage tubes.

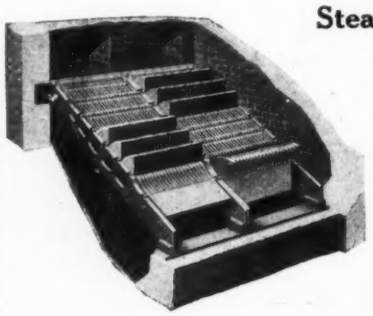
Mr. Engineer here is your opportunity to show your boss some savings.

Roto Cleaners are made for Fire Tube and Water Tube Boilers, Condensers, Evaporators, etc. Write for our offer to prove Roto Cleaners can make this saving in your power plant.

THE ROTO COMPANY, 76 Temple Street Hartford, Conn.



Increased Steam Production



Don't buy new boilers—until you are certain that it is necessary.

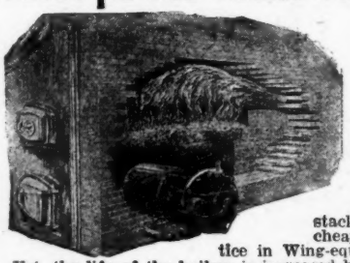
The installation of PERFECTION HAND STOKERS will increase the steaming capacity of your present boilers, and at the same time will permit cheaper coals to be burned.

They save money to their owners and much back breaking labor to the firemen.

Write for Bulletin.

PERFECTION GRATE & SUPPLY CO.
Springfield, Mass.

More power without more boilers with the Wing Turbine Blower



The Original-The Standard

150%, 200% and higher ratings from boilers, even when connected with small stacks, and when burning the cheapest coal, is common practice in Wing-equipped boiler plants.

Yet, the life of the boilers is increased because cold air is prevented from entering the firedoors and producing contracting strains.

All of which is more fully discussed, with actual results in 16 typical power plants, in the Wing Blower Book. In justice to yourself, send for it today!

L. J. Wing Mfg. Co. 9th Ave. and 13th St., NEW YORK
Offices in Principal Cities.

Marion Hand Fired Stokers

Interlocking teeth of special shape present irregular openings which will not permit the loss of live coals or unburned fuel. Nothing but fine ash can drop through into the ash pit.

Movement of the fuel bed is positive and continuous from step to step over the grate toward the dumping plate. Every bit of energy from the coal is extracted by this economical clean method of firing.

Marion Machine Foundry & Supply Co.
Marion, Indiana

MARION POWER PLANT EQUIPMENT

Morehead Back to Boiler SYSTEM

Feed Your *Boilers* Pure Water HOT!

HOW much of your fuel are you wasting each month? To save all of the costly heat units it generates you must get the condensation back to the boilers while it is HOT.

The "*Morehead*" book will tell you *how.*

Ask for your copy AT ONCE.

Morehead Mfg. Co., Dept. E. **Detroit, Mich.**
309

Vogt PRODUCTS

REFRIGERATING AND ICE MAKING MACHINERY—WATER TUBE & HORIZONTAL RETURN TUBULAR BOILERS DROP FORGED STEEL VALVES & FITTINGS—OIL REFINERY EQUIPMENT—*Ask for Bulletins*

HENRY VOGT MACHINE CO., Manufacturers, Louisville, Ky.

Roach Stokers

Mechanically Simple Economical Easily Operated

ROACH STOKER COMPANY

Presser Building, Philadelphia

SIL-O-CEL

MADE FROM CELITE
Insulating Brick and Powder

Saves 60 per cent to 70 per cent of the heat lost through boiler walls and settings. Write for Bulletin K-6A.

CELITE PRODUCTS COMPANY
New York, Philadelphia, Cleveland, Detroit, Chicago, St. Louis, New Orleans, Denver, Los Angeles, San Francisco.

CYCLONE GRATES

make *all* of your fuel count in power. *Write for full details.*

CYCLONE GRATE BAR CO.
Buffalo, New York

HUBER HAND STOKER

Sole Manufacturers
FLYNN & EMRICH COMPANY, Baltimore, Maryland

Radial Brick Chimneys

Alphons Custodis Chimney Construction Co.

Also Experts in
Repairing Brick and Concrete Chimneys
Heightening Chimneys
Lightning Rods Installed and Repaired
Work done while chimney is in operation, if necessary.
95 Nassau Street, New York City

Files Stokers
Hand Operated

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P. O. Box 386-4
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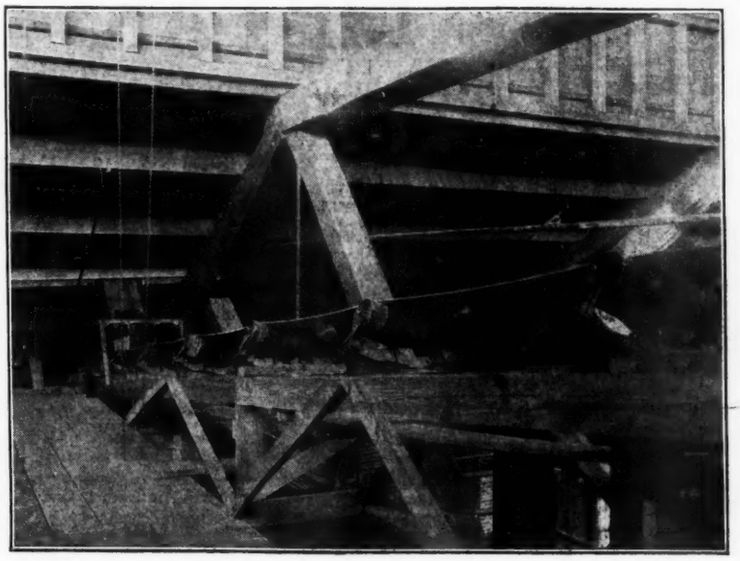
Keep a barrel or two on hand for emergency repairs



STEARNS

MATERIAL HANDLING METHODS

TRADE MARK

STEARNS CONVEYOR CO.

Cut your material handling costs now by installing present-day machinery.

Stearns equipments are built for long life and low maintenance cost.

Mechanical handling reduces production wastes by eliminating hand labor.

Stearns engineers backed by twenty years of experience can solve your conveying problems.

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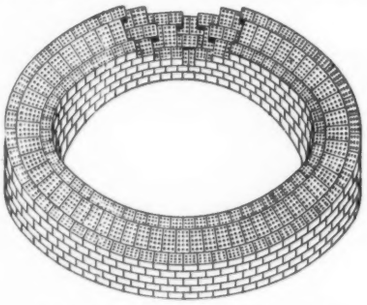
The Stearns Conveyor Co.

East 200th St. and St. Clair Ave., CLEVELAND, OHIO

National Chimney Construction Co.



Radial Brick
and
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Chimneys

800 Title Guaranty Bldg., St. Louis, Mo.

LIPTAK

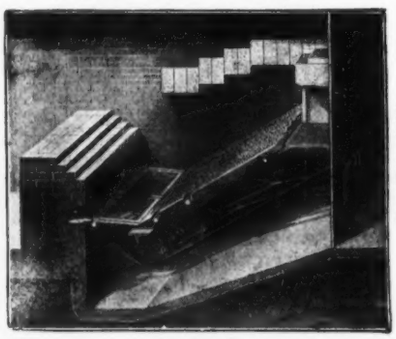
Liptak Double Suspension Arch
Liptak Single Suspension Arch
Liptak Furnace Wall Support

If you are interested in reducing upkeep costs let us advise with you.

Write for detailed information

Liptak Fire-Brick Arch Company
846 Builders Exchange, Minneapolis, Minn.

YOU can burn the cheapest grades of coal without smoke with



NATIONAL STOKERS

Equals the full load efficiency of the best mechanical stoker—minus the high initial and upkeep expense of the latter.

Write for full details.

M. A. Hofft Co.
Indianapolis, Ind.

FLAME BRAND

HIGH TEMPERATURE CEMENTS

Red Flame Plastic Cement
Blue Flame Fire Brick Cement
White Flame Insulating Cement
Highgrade Fire Brick

KING REFRACTORIES CO. INC.
NEW YORK OFFICE 707 GREENWICH ST.
MAIN OFFICE & WORKS 1709 NIAGARA ST., BUFFALO, N.Y.
Write for Circular "P"

Labor, Time and Fuel Saving

The Neemes Grate shakes out the ashes, cuts out clinkers and dumps the fire, without the necessity of opening the fire doors. *Write for further information.*

NEEMES BROTHERS, INC.
41-49 Adams Street, Troy, New York
BRANCH OFFICES:
New York Philadelphia Chicago Baltimore
Montreal Providence Columbus St. Louis

Only Fools Take Chances

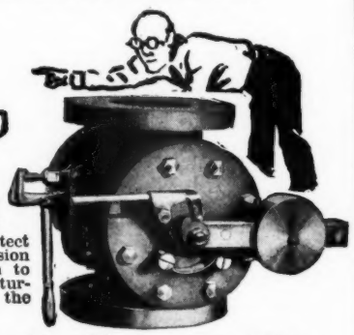
The Wise Man Installs The

Falls

Engine Stop

He knows that it will protect him from a flywheel explosion and that it will enable him to instantly stop his engine or turbine from distant points in the plant.

Write us for full details.



Jenkins Machine Co., Sheboygan, Wis.

Belt User's Book Free

Users find it helps them to get the most from their belts. Students ask for it because it gives them the practical side of belt usage without much of the technical.

Mailed gratis on request.

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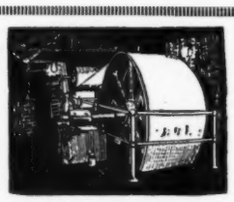

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"STEEL MIXTURE"
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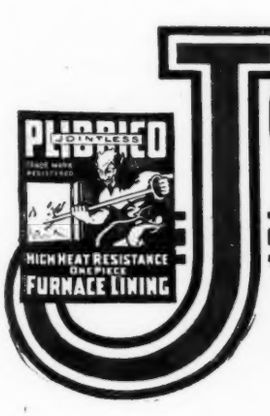

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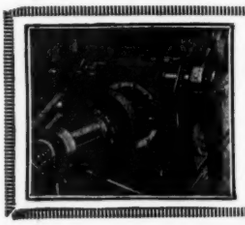

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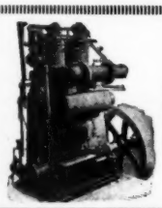

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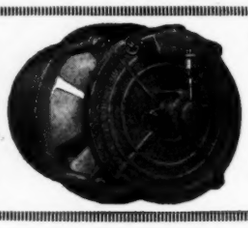

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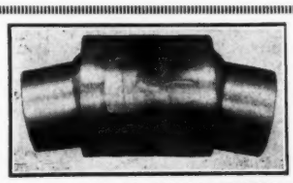

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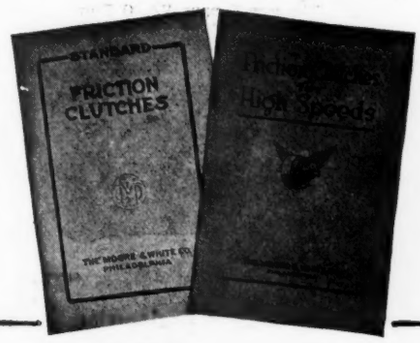

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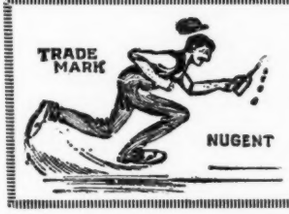

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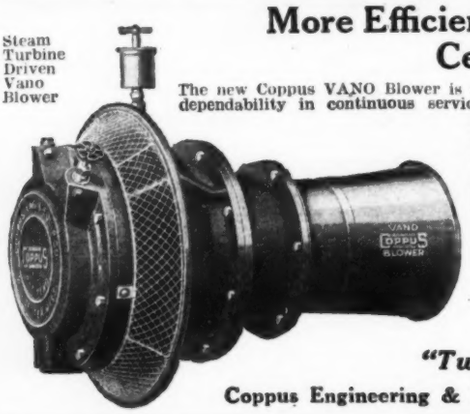

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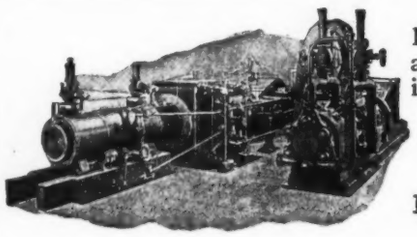

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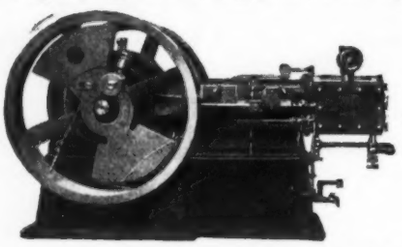

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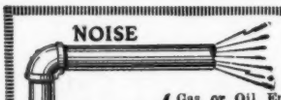

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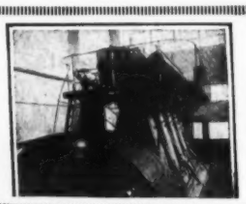

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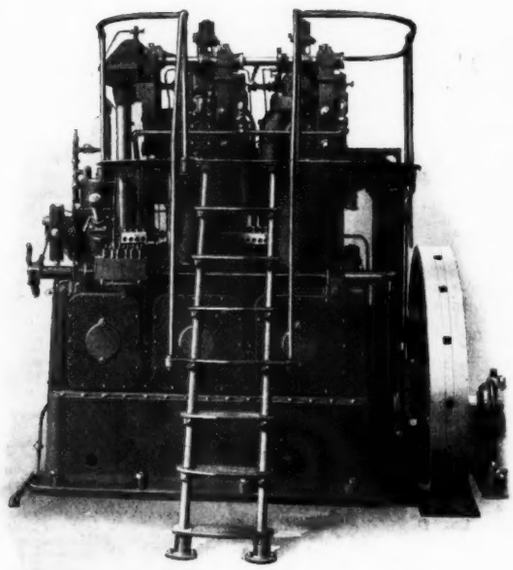

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Vertical and Horizontal

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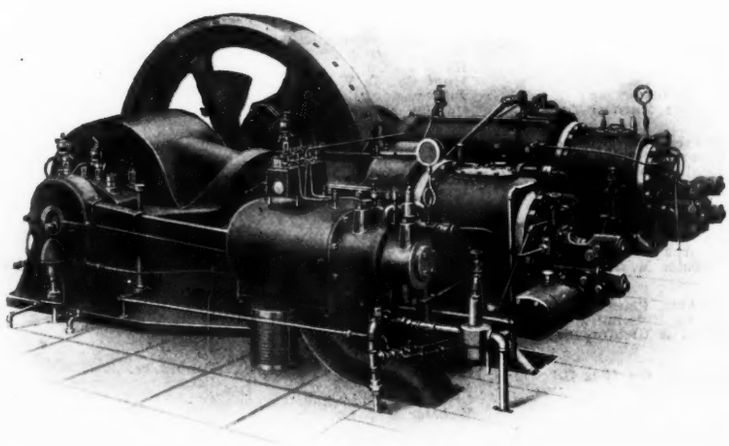

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Built by the
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See Last Page for Alphabetical Index

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Ideal Commutator Dresser Co.

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Fulton Iron Wks.
Gardner Governor Co.
Sullivan Machry. Co.

Condenser Tube Cleaner
Lagonda Mfg. Co.

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Allis-Chalmers Mfg. Co.
American Well Works
Buffalo Forge Co.
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Elliott Co.
Griscom-Russell Co.
Ingersoll-Rand Co.
Westinghouse Elec. & Mfg.
Wheeler Cond'r & Engr. Co.
Wheeler Mfg. Co., C. H.

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Ingersoll-Rand Co.
Wheeler Cond'r & Engr. Co.
Wheeler Mfg. Co., C. H.

Condensers, Distilling
Ross Heater & Mfg. Co.
Wheeler Cond. & Eng. Co.

Condensers, Jet
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Elliott Co.
Ingersoll-Rand Co.
Manistee Iron Works
Wheeler Cond. & Eng. Co.
Wheeler Mfg. Co., C. H.

Condensers, Surface
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Elliott Co.
Ingersoll-Rand Co.
Wheeler Cond. & Eng. Co.
Wheeler Mfg. Co., C. H.

Conduits, Underground
American District Steam Co.

Connectors, Frankel Solderless
Westinghouse Elec. & Mfg. Co.

Controllers, Electric
Westinghouse Elec. & Mfg. Co.

Conveyors, Belt
Guarantee Construction Co.
Jeffrey Mfg. Co.

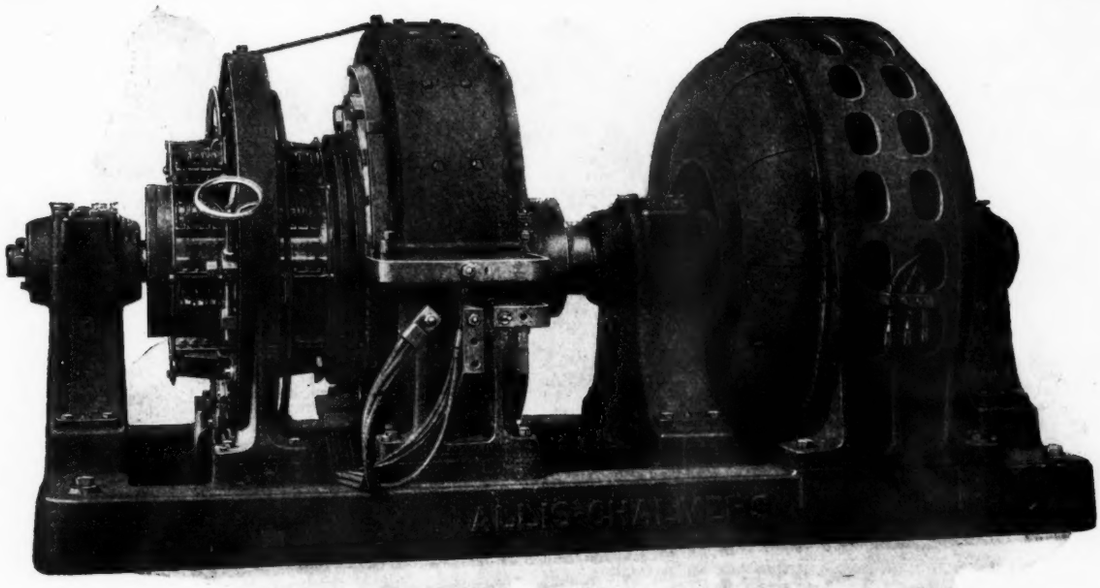
Conveyors, Cable
Conveyors Corp. of America
Stearns Conveyor Co.

Conveyors, Coal and Ash
(See Coal and Ash Handling Machinery)

Conveyors, Soot
Conveyors Corp. of America

Coolers
Griscom-Russell Co.
Vogt Mach. Co., Henry

ALLIS-CHALMERS



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OF ANY CAPACITY
AND FOR
ALL CLASSES OF SERVICE

Synchronous Motor can be furnished for Power Factor correction when desired.

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Hydraulic Turbines
Pumping Engines
Centrifugal Pumps
Mining Machinery
Metallurgical Machinery
Crushing Machinery
Cement Machinery
Flour Mill Machinery
Saw Mill Machinery
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Air Brakes
Steam and Electric Hoists
Farm Tractors
Power Transmission Machinery

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Milwaukee, Wisconsin

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Spray Engineering Co.
Yarnall-Waring Co.

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Wheeler Mfg. Co., C. H.
Wheeler Cond. & Engr. Co.

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Smith & Serrell

Couplings, Rigid
Smith & Serrell

Couplings, Shaft
Nicholson & Co., W. H.
Smith & Serrell

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Excello Mfg. Co.

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Magnesia Assn. of America
Ric-Wil Co.

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Ric-Wil Co.

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Orton & Steinbrenner Co.
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Sun Co., The

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Westinghouse Elec. & Mfg. Co.

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(See Pipe Cutters)

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Underwood & Co., H. B.

Dashpots
Underwood & Co., H. B.

Dealers
(See Searchlight Section)

Die Stocks
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Griscom-Russell Co.

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(See Blowers, Fan)

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Terry Steam Turbine Co.

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Vogt Machine Co., Henry

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Green Fuel Economiser Co.

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Lunkenheimer Co.
Manning Maxwell & Moore, Inc.

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Jeffrey Mfg. Co.
Orton & Steinbrenner
Stearns Conveyor Co.

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(See Directory)

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Rooksby & Co., E. J.
Underwood & Co., H. B.

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Strong Carlisle & Hammond Co. The

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McIntosh & Seymour Corp.
Taylor Machine Co.

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Fulton Iron Wks.
Hadfield-Penfield Steel Co.
Ingersoll-Rand Co.
Taylor Machine Co.
Westinghouse Elec. & Mfg. Co.

Engines, Pumping
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Engines, Steam
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Brownell Co.
Buckeye Engine Co.
Buffalo Forge Co.
Chicago Pneumatic Tool Co.
Fitchburg Steam Engine Co.
Fulton Iron Wks.
Kerr Turbine Co.
Troy Eng. & Mach. Co.
Vilter Mfg. Co.
Westinghouse Elec. & Mfg. Co.

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Evaporator Feed Heaters
Griscom-Russell Co.

Evaporators, Multi-Stage
Wheeler Cond. & Engr. Co.

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Direct Separator Co.
Hoppes Mfg. Co.
Patterson-Kelley Co., Inc.
Watson & McDaniel Co.

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Griscom-Russell Co.
Howard Iron Wks.
Nelson Valve Co
Ross Heater & Mfg. Co.
Webster & Co., Warren
Wheeler Mfg. Co., C. H.

Fans, Exhaust and Ventilator
(See Blowers, Fan)

Feed Water Filters
(See Filters, Feed Water)

Feed Water Heaters
Elliott Co.
Griscom-Russell Co.
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Hoppes Mfg. Co.
Patterson-Kelley Co.
Permutit Co.
Warren Webster & Co.
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Hoppes Mfg. Co.
International Filter Co.
Permutit Co.
Ross Heater & Mfg. Co.
Webster & Co., Warren
Yarnall-Waring Co.

Feed Water Regulators
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Elliott Co.
Mason Regulator Co.
Northern Equipment Co.
Squires Co., C. E.
Wing Mfg. Co., L. J.

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Lunkenheimer Co.
Richardson-Phenix Co.

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Richardson Phenix Co.

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Griscom-Russell Co.

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Filters, Water
International Filter Co.
Permutit Co.
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Detrick Co., M. H.
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Fittings, Oil Pipe Union Cinch
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Flanges
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Dart Mfg. Co., E. M.
Jefferson Union Co.
Jenkins Bros.
Pittsburgh Piping & Equipt. Co.
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Flat Wire—Strip Steel
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Reliance Gauge Column Co.

Flow Meters
(See Meters, Flow)

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Forges
Buffalo Forge Co.

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Sun Co., The

Fuel Oil System
Wayne Oil Tank & Pump Co.

Furnace Blocks
McLeod & Henry

Furnace Control Equipment
Automatic Fuel Saving Co.

Furnace Door Arch
Betson Plastic Fire Brick Co.
Detrick Co., M. H.
Jointless Fire Brick Co.
McLeod & Henry Co.

Furnace Lining
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Green Fire Brick Co., A. P.
Jointless Fire Brick Co.
McLeod & Henry
Quigley Furnace Specialties Co.

Furnace, Walls
Liptak Fire Brick Co.

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Green Engineering Co.
Hofft Co., M. A.
Illinois Stoker Co.
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Murphy Iron Works
Roach Stoker Co.

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Garlock Packing Co.

Gage Testing Outfit
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Gages, Differential
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Gages, Draft
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Bristol Co.
Defender Automatic Regulator Co.
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Pierce Co., Wm. B.

Gages, Liquid Level
Foxboro Co.

Gages, Oil
Richardson-Phenix Co.

Gages, Pressure
Ashton Valve Co.
Bristol Co.

Gages, Recording
Am. Steam Gauge & Valve Mfg. Co.
Ashton Valve Co.
Bristol Co.
Foxboro Co.
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Gages, Vacuum
Ashton Valve Co.
Bristol Co.
Greene, Tweed & Co.

Gages, Water
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Greene, Tweed & Co.
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Lunkenheimer Co.
Reliance Gauge Column Co.

Gas Exhausters
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General Electric Co.
Kerr Turbine Co.
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Terry Steam Turbine Co.
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Mason Regulator Co.
Northern Equipment Co.

Governors, Pump
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Chaplin-Fulton Mfg. Co.
Davis Regulator Co., G. M.
Edward Valve & Mfg. Co.
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Mason Regulator Co.
Northern Equipment Co.
"S-C" Regulator Co.
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Watson & McDaniel Co.
Webster & Co., Warren

Governors, Steam Engine
Gardner Governor Co

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Greene, Tweed & Co.

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Cokal Stoker Corporation

Grates
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Babcock & Wilcox Co., The
Combustion Eng. Corp.
Cyclone Grate Bar Co.
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Flynn & Emrich
Green Engineering Co.
Hofft, M. A., Co.
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Ohio Grease Co.
Sun Co., The

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Conveyors Corp. of America
Shepard Elec. Crane & Hoist Co.

Hoppers, Coal and Ash
Brown Hoisting Mchy. Co.
Conveyors Corp. of America
Green Engineering Co.
Jeffrey Mfg. Co.

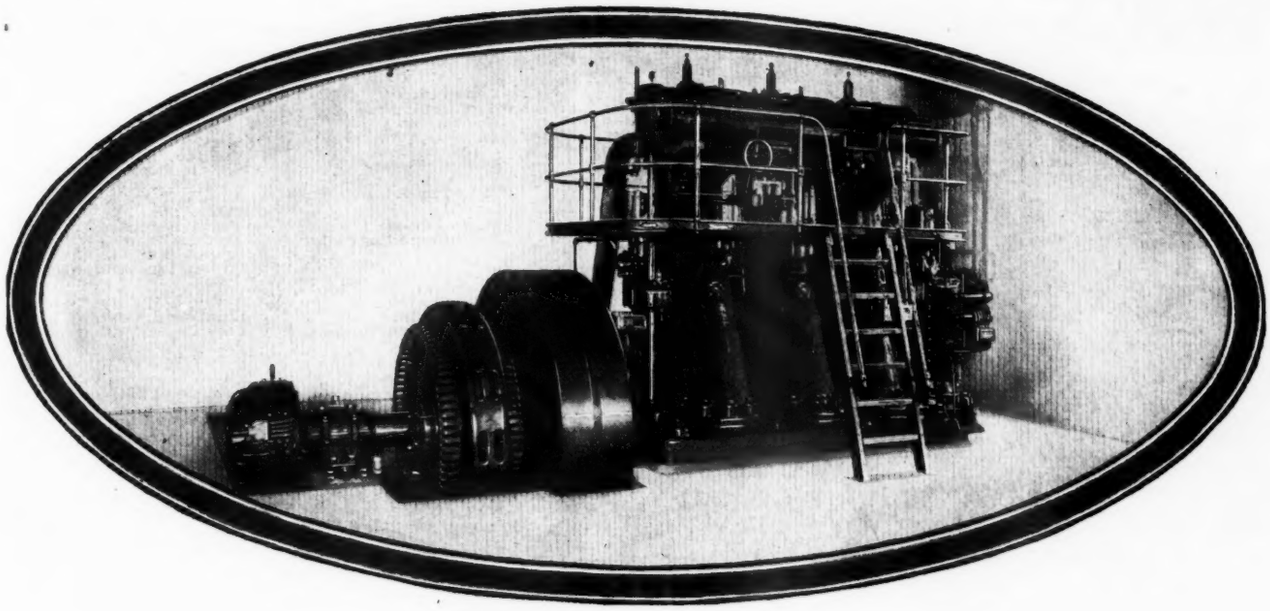
Hose, Air
Chicago Pneumatic Tool Co.

Hose, Clamps
Chicago Pneumatic Tool Co.

Hose, Rubber
Pioneer Rubber Mills
Quaker City Rubber Co.

Ice Machine Repairs
Underwood & Co., H. B.

Ice and Refrigerating Machinery.
(See Refrigerating Machinery)



Low Maintenance Expense that Means High Returns

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There are no boilers, stacks or other cumbersome and short-lived equipment in a Fulton Diesel Engine plant. The power plant is reduced to the simplest proportions, because a Fulton Diesel Engine is the nearest perfect of any prime mover that can be built.

Thus, in addition to big savings in fuel and labor, the Fulton Diesel Engine increases the returns to the producer of power by the economy with which it can be kept in perfect running order.

Facts to Remember About the Fulton Diesel

A compact self-contained power plant.
For all power purposes in units from 150 to 1,000 horsepower.
In most cases shows clear savings of two-thirds over fuel consumption under boilers.
Thermal efficiency:
Steam—15% maximum.
Diesel—36% net.
Fuel consumption in direct proportion to load.
Uses cheap fuel.
Constant readiness for operation without stand-by losses.
Quick and easy starting.
Economy independent of size.
Long life with constant efficiency.
Easily operated and maintained by any competent steam engineer.

Our new Bulletin No. 801, describing and illustrating the Fulton Diesel Engine and containing other valuable information, will be mailed upon request.

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Successful Engine Builders for 69 Years

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Biddle, James C.

Indicators, Steam Engine
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Lunkenheimer Co.
Manzel Bros. Co.
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Westinghouse Elec. & Mfg. Co.

Lamps, Incandescent
Westinghouse Elec. & Mfg. Co.

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Leather Lace
Schieren Co., Chas. A.

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Custodus Chimney Constr. Co., Alphons

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Lunkenheimer Co.
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Powell Co., Wm.
Richardson-Phenix Co.

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Ingersoll-Rand Co.
Lunkenheimer Co.
Powell Co., Wm.
Richardson-Phenix Co.

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Richardson-Phenix Co.

Lubricating Oil Filtering, Tanks and Pumps
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Republic Flow Meters Co.

Meters, Boiler
Bailey Meter Co.

Meters, Coal
Bailey Meter Co.
C. J. Mfg. Co.

Meters, Feed Water
Bailey Meter Co.
Builders Iron Fdry.
Republic Flow Meter Co.
Webster & Co., Warren
Yarnall-Waring Co.

Meters, Flow
Cory & Son, Inc., Chas.
Bailey Meter Co.
Builders Iron Fdry.
Republic Flow Meters Co.
Yarnall-Waring Co.

Meters, Gas
Bailey Meter Co.
Builders Iron Foundry
Republic Flow Meters Co.

Meters, Oil
Builders Iron Foundry
Republic Flow Meters Co.
Richardson-Phenix Co.

Meters, Steam
American District Steam Co.
Bailey Meter Co.
Builders Iron Foundry
Republic Flow Meters Co.

Meters V-Notch
Bailey Meter Co.
Hoppes Mfg. Co.
H. S. B. W. Cochrane Corp.
Yarnall-Waring Co.

Meters, Water
American District Steam Co.
Bailey Meter Co.
Builders Iron Foundry
H. S. B. W. Cochrane Corp.
Hoppes Mfg. Co.
Republic Flow Meters Co.
Yarnall-Waring Co.

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Crocker-Wheeler Co.
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Roto Co.

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Griscom-Russell Co.

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Lunkenheimer Co.
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Powell Co., Wm.
Richardson-Phenix Co.

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Oil Purifiers
Richardson-Phenix Co.

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Coatesville Boiler Wks.
Elliott Co.
Richardson-Phenix Co.

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(See Separators, Oil)

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Lunkenheimer Co.
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Richardson-Phenix Co.
Vogt Machine Co., Henry
Wayne Oil Tank & Pump Co.

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The Sun Co.

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Crandall Packing Co.
Sarco Co.

Packing, Cylinder
Rooksby & Co., E. J.

Packing, Flax
Chesterton Co., A. W.

Packing, Hydraulic
Advance Packing & Supply Co.
Chesterton Co., A. W.
Crandall Packing Co.
Garlock Packing Co.
Goetze Gasket & Pkg. Co.
Schieren Co., Charles A.
Walker & Co., Ltd., Jas.

Packing, Leather
Schieren Co., Charles A.

Packing, Metallic
Crandall Packing Co.
Garlock Packing Co.
Merrill & Co., Wm. B.
Walker & Co. Ltd., Jas

Packing, Piston
Chesterton Co., A. W.

Packing, Pump Valve
Garlock Packing Co.

Packing, Rod
Chesterton Co., A. W.
Crandall Packing Co.
Garlock Packing Co.
Goetze Gasket & Pkg. Co.
Greene, Tweed & Co.
Merrill & Co., Wm. B.
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Quaker City Rubber Co.

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Garlock Packing Co.
Greene, Tweed & Co.
Jenkins Bros.
Pioneer Rubber Mills
Quaker City Rubber Co.
Walker & Co., Ltd., Jas.

Packing, Valve Stem
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Garlock Packing Co.
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Superheater Co.

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Trimont Mfg. Co.

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Jefferson Union Co.
Pittsburgh Piping & Equipt. Co.
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American District Steam Co.

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Crane Co.
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Evertyte Piston Ring Division

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Plant Communication System
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Ingersoll-Rand Co.

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Cresson-Morris Co

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Schutte & Koerting Co.

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Caldwell, W. E. Co., Inc.
Greene, Tweed & Co.
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Combustion Engineering Corp.
Fuller Lehigh Co.
Jeffrey Mfg. Co.

Pumps, Acid
Davidson Co., M. T.

Pumps, Air
Croll-Reynolds
Davidson Co., M. T.
Wheeler Condenser & Engr. Co.
Wheeler Mfg. Co., C. H.

Pumps, Boiler Feed
Buffalo Forge Co.
Coppus Engr. & Equip. Co.
M. T. Davidson Co.
Earle Gear & Machine Co.
Farnsworth Company
Gardner Governor Co.
Goulds Mfg. Co.
Ingersoll-Rand Co.
Kerr Turbine Co.
Manistee Iron Works
Morris Machine Wks.
Warren Steam Pump Co.

Pumps, Brine
M. T. Davidson Co.

Pumps, Centrifugal
Alberger Pump & Condenser Co.
Allis-Chalmers Mfg. Co.
Buffalo Forge Co.
Coppus Engr. & Equip. Co.
Earle Gear & Machine Co.
Goulds Mfg. Co.
Ingersoll-Rand Co.
Kerr Turbine Co.
Manistee Iron Works Co.
Morris Machine Works
Taber Pump Co.
Terry Steam Turbine Co.
Westinghouse Elec. & Mfg. Co.
Wheeler Condenser & Engr. Co.
Wheeler Mfg. Co., C. H.

Pumps, Condenser
Davidson Co., M. T.
Farnsworth Company
Goulds Mfg. Co.
Kerr Turbine Co.
Wheeler Mfg. Co., C. H.

Pumps, Deep Well
Davidson Co., M. T.
Goulds Mfg. Co.
Vacuum Oil Co.

Pumps, Fire
Gardner Governor Co.
Goulds Mfg. Co.

Pumps, Force Feed (See Lubricators)

Pumps, Elevator
Davidson Co., M. T.
McGowan Co., John H.

Pumps, Grease
Richardson-Phenix Co.

Pumps, Mine
Goulds Mfg. Co.
M. T. Davidson Co.
Ingersoll-Rand Co.
Manistee Iron Works Co.

Pumps, Oil
M. T. Davidson Co.
Gardner Governor Co.
McGowan Co., John H.
Nugent & Co., W. W.
Richardson-Phenix Co.

Pumps, Power
Gardner Governor Co.
McGowan Co., John H.
Warren Steam Pump Co.

Pumps, Rotary
Taber Pump Co.

Pumps, Steam
Buffalo Forge Co.
Davidson Co., M. T.
Gardner Governor Co.
Kerr Turbine Co.
McGowan Co., The John H.
Terry Steam Turbine Co.
Warren Steam Pump Co.
Wheeler Condenser & Engr. Co.

Pumps, Turbine
Allis-Chalmers Co.
Kerr Turbine Co.
Manistee Iron Works

Pumps, Vacuum
Buffalo Forge Co.
Chicago Pneumatic Tool Co.
Croll-Reynolds
Davidson Co., M. T.
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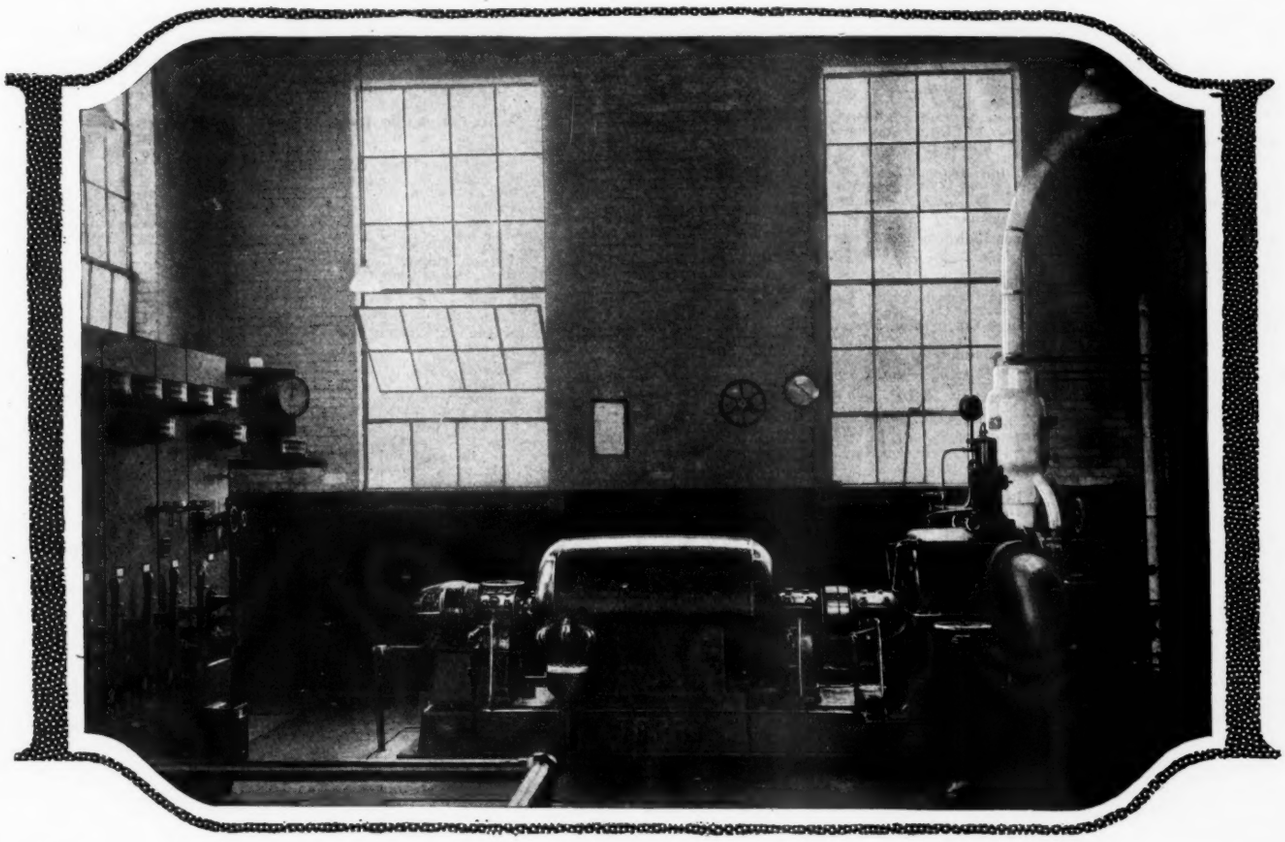

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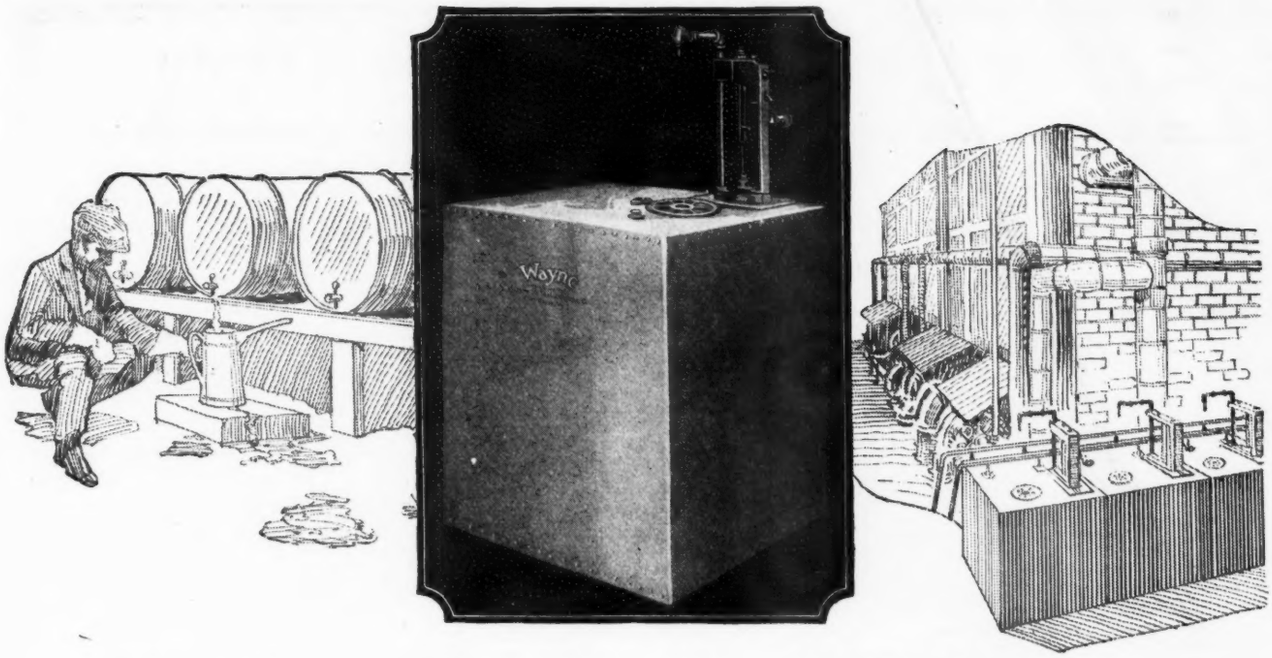

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